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APPLICATION OF SCIENCE IN INDUSTRY

THE Messel Memorial Lecture, "The Strategy of Science", which Sir Henry Tizard delivered to the Society of Chemical Industry in Aberdeen on July 9, is above all a challenge to constructive and penetrating thinking about the balance of research effort in Britain, its orientation and distribution as between industry, government and the universities, and the development of technical and technological education. It indicates, rather than asks, the questions which should be put and answered before policy in such matters is determined, and in this way provides the atmosphere in which the recent report of the Advisory Council on Scientific Policy in presenting the report of its Committee on Manpower, or the more recent survey of scientific and industrial research in British industry of the Federation of British Industries, should be examined. It lends strong support to some of the recent representations made to the Lord President of the Council by the Parliamentary and Scientific Committee (see *Nature*, August 16, p. 267).

Sir Henry's address (*Chemistry and Industry*, August 16, p. 788) is, in fact, largely an exposition of the theme that large endowments afford no assurance that research will be wisely and profitably directed. Money can be wasted on research as easily as on anything else, and his discourse stems essentially from a typically shrewd comment made to him many years ago by Lord Rutherford on learning of a large endowment for research received by a physics laboratory in the United States : "We haven't any money", remarked Lord Rutherford, "so we've got to think" ; and the core of Sir Henry's address lies in his insistence that it is imperative for us to select the right targets in research and development. We cannot afford to waste first-class men on second-class objectives. We must think out the objectives that really matter, and then be bold and adventurous. Without adventure in industry Great Britain is doomed to decay.

Sir Henry took a sombre view of Great Britain's economic position ; he thinks that the present state of instability is likely to persist. He went so far as to suggest that lack of industrial effort and failure to apply the right policy are due at least in part to insufficient realization of the serious state of affairs. This in turn is due, he believes, to the neglect of political leaders to explain frankly to the working population the dangerous condition of the economic structure of Britain. So far from that being one of temporary instability due to the War or to the mistakes of politicians since the War, for many years before the Second World War we had been in a state of unstable equilibrium, exposed to the force of any adverse world event outside of our own control. He believes that the ultimate solution of the economic problem of Great Britain will only be found in a better distribution of the population throughout the British Commonwealth. Even as an agreed policy, such a redistribution would take a long time to effect.

Meanwhile, we must endeavour to balance our trade as best we can by exporting what the world wants and needs, in the face of severe competition. This obviously depends largely on the good judgment with which science is applied to industry, and especially on the swiftness with which action is taken to secure the appropriate balance between science and technology. Sir Henry did not conceal his impatience for action rather than talk.

It is from this point of view that Sir Henry urged that strategy is more important than tactics. By the strategy of science he means the art of so directing the application or advance of science as to ensure the most rapid progress of society, or of knowledge. Tactics, on the other hand, is the procedure or skilful devices calculated to gain the strategical end, or in another word, 'research'. The strategy of the application of science to industry must depend not only on available tactical skill and knowledge, but also on the economic circumstances of different countries. It demands constant fresh and flexible thinking about our economic circumstances and searching inquiry as to our reasons and objectives.

Curiously enough, although it is apparent that Sir Henry believes that some redistribution of population is required as a long-term policy—and such redistribution has obvious implications for both the industrial and the economic strategy of Great Britain—he does not here consider specifically their bearing. The strategy he advocates for science is clearly to be based on fresh thought about all issues, but in the first place he suggests we should concentrate on the effective application in industry of existing knowledge. As in his presidential address to the British Association four years ago, he urges that this is our first need. We are still paying too much attention to fundamental research in industry, and too little to the need for development and skilled application. A more severely practical view of industrial research is essential if we are to recover economic stability, and Sir Henry quoted with approval the article on the role of science in the British economy in which Dr. R. L. Meier developed this theme two years ago. We must concentrate our efforts, he said, on those projects which will help to restore the balance of trade, directly or indirectly, as quickly as possible, and be careful to avoid dispersing them over too wide a field. Not until we have an overall balance of trade in our favour for at least five successive years can we afford, Sir Henry thinks, to spend much time, thought or money on developments which, however desirable in a perfect world, are not vital to our existence. Neither the scientific prestige of the nation nor the quality of scientific education is likely to suffer by such a policy of strengthening our technology rather than expanding our science.

Sir Henry's note of urgency in this connexion reinforces the representations made to the Lord President of the Council by the Parliamentary and Scientific Committee on July 28; but there is a further point which is causing Sir Henry some concern. Referring to the bearing of judgment on the selection of the right objectives as a prelude to any redistribution in our research effort, and the consequent difficulties in reaching agreement as to the targets that matter, he pointed out that we have still to secure concerted action. No common policy, for example, has yet been agreed by the nationalized fuel industries, and even in the most scientific of British industries, the chemical industry, there is reason for disquiet. The highest executive positions in such industries have long been occupied by well-known men of science or technologists; and the various companies which make up, for example, the chemical industry, would pass all ordinary tests of technical or financial efficiency with ease. Nevertheless, the industry is apparently not succeeding in competing in the world market. The British share of world trade in chemicals has been slowly declining since 1913, when the condition of the chemical industry was very different, and in spite of the high standard of chemical science in Britain and the large expenditure of the industry on research.

Sir Henry does not believe that this can be attributed to the quality of chemists engaged on research in the industry being lower than in other countries. Nor does he appear to blame faulty judgment on the part of the directorate of the industry—though some chemists may think he is less than fair to the British industry in his remarks regarding the exploitation in other countries of the discoveries of British industries. Still less does he attribute it to inadequate financial resources. In defence research and development, he remarks, we do not spend one-fifth of what is spent in the United States, but we have held our own, and have often led the way.

Shortcomings, in Sir Henry's view, appear to be mainly due to slowness of production from the prototype to the full scale. For this, two factors are chiefly responsible: first, a fiscal policy which discourages enterprise and adventurousness, and second, obsolete social attitudes and trends in the educational field which hinder as many boys of outstanding ability as is desirable in the national interest from entering on a scientific career. This second is a consideration which is fundamental to the development of higher technological education.

Sir Henry's forthrightness on the first point is highly significant, coming from one who has recently retired from the chairmanship of both the Advisory Council on Scientific Policy and the Defence Research Council. Possibly his release from official responsibilities may leave him freer to urge publicly views based on his own wide experience, which may yet require a large measure of public support to secure their adoption by official establishments not yet awake to the implications of the strategy of science. Meanwhile, his position with the National Research Development Corporation has not inhibited him from voicing his misgivings as to the possible adverse effect of such experiments on the adventurousness of industry. Sir Henry recognizes that the Corporation has important functions to fulfil. He sees none the less that, in discharging them, there is a real danger that industry may be encouraged to expect the nation to carry the financial risks of development.

Sir Henry's misgivings on this score are justified by reference to the engineering industry. He main-

tains that in recent years defence research and development at the cost of the taxpayer, rather than private enterprise, have provided the chief stimulus to British engineering of the highest quality. In his judgment, more money is spent by the taxpayer on engineering development than is spent by all the engineering industries put together, and he fears that there is danger of this spreading, and of the taxpayer having to take risks which formerly were taken by private enterprise.

The strategy of science in Britain, accordingly, must take account of the distribution of research between industry and government institutions, as well as between industry and the universities. There are important questions to be considered before allocating the execution of a particular project that is rightly judged essential to the national interest as between industry or a government institution; where the project is carried out may not prove to be a secondary matter. It may affect vitally the stimulation or encouragement of the skill, originality and enterprise which, whether in engineering or in other fields, must be allied to research, development and design if we are to increase our share of the world's trade. Sir Henry has already formed the conclusion that the springs of enterprise in Britain are running down, and that unless industry is able and allowed to increase its capital expenditure, and does it wisely, it is idle for scientific men to complain that their discoveries are exploited elsewhere.

Our strategy must thus first and foremost encourage enterprise, and as one element it must break with the present practice of leaving the responsibility for deciding whether any branch of industry shall spend anything on new ventures largely with Civil servants in government departments. A thorough and thoughtful analysis of Government expenditure on civilian research, particularly in relation to production, and its organization, might also yield some useful tactical suggestions. But the main threat to industrial enterprise in Britain lies in taxation policy, and no strategy will be adequate which does not insist on the removal of financial as well as other elements which discourage adventure in industry or in science. Nor should it be forgotten that financial restrictions and controls can also discourage enterprise and lead to far-reaching delays and frustration, apart from a serious waste of scientific and technical man-power. Such consequences are sufficiently serious to warrant the wish that every existing restriction or control could be reviewed and no new one promulgated apart from the critical and constructive thinking implied in Lord Rutherford's remark, "We haven't any money so we've got to think".

Sir Henry's strategy of science demands above all creative and critical thought and a spirit of adventure. To develop skill and originality, to foster adventurousness and sound judgment, to select the right objectives and to distribute wisely our limited resources of man-power and materials are the main elements; and some clear indications are given as to the tactics to be used, notably in the field of technical and technological education, where Sir Henry's impatience for action is manifest. Here he calls for a determined effort to overcome a difficulty referred to by the Advisory Council on Scientific Policy and discussed at a greater length in a second article by Dr. R. L. Meier, "Research as a Social Process", in the *British Journal of Sociology* last year. Sir Henry condemns the kind of intellectual snobbery which discourages many an able man from studying technology at a university; our tactics must be calculated to break down such snobbery and all other attitudes which discourage a sufficient proportion of the ablest minds of each generation from entering on careers in science and technology, or moving freely within those spheres whether in industry, the universities or the departments of State. Dr. Meier in his second article points out that the evolution of the organization of research has been in conflict with the traditional values of the man of science, and the distribution of our research effort has been determined by social status more than is commonly realized. An adequate strategy of science must take full account of such factors and their effect on specialization, as well as on the communication between groups. It must provide the tactics for enticing more of the ablest intellects, who would otherwise limit their activities to science, into responsible positions in industry and in applied research, and for encouraging the training in our educational system of those capable of forging links between the different disciplines, thus carrying further the type of co-operation that has proved outstandingly successful in what is known as 'operational research'.

Scientific workers and industry in general are much indebted to Sir Henry Tizard for his stimulating and suggestive Lecture. Their response to his imperative and urgent call to action as well as to thought could do much to impel Government action in some fields where it has been long overdue.

BIOCHEMISTRY AND BIOLOGY OF ANTIMETABOLITES

A Study of Antimetabolites

By D. W. Woolley. Pp. xiii+269. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1952.) 40*s*. net.

THE publication of "A Study of Antimetabolites" is most timely, and, when it is written by a master of the subject like Dr. D. W. Woolley, of the Rockefeller Institute for Medical Research, it is certain to receive a most hearty welcome. The subject has had a slow and difficult birth from the time Ehrlich, in developing his experiments on immunity and, later, on chemotherapy, propounded the idea of 'receptors', and so emphasized that chemical specificity is a dominant factor in cell life. This was followed in the enzymic field of study by the discoveries of Michaelis (1910–14) and his collaborators that some inhibitors are similar in chemical structure to the products of the reaction. In Great Britain the extension of the idea of antagonism of enzymic action to analogues came to the fore with the work of Quastel and Wooldridge in 1927, when they described the competitive inhibition of succinic dehydrogenase by malonic acid, a structural analogue

of the substrate of the enzyme. Other work which supported this conception came gradually to light, but the great modern interest and eagerness to examine the hypothesis began seriously when Woods in 1940 extended the subject to the chemotherapeutic field by reporting that the bacteriostatic action of sulphanilamide and related sulphonamide drugs was reversed completely and competitively by *p*-amino benzoic acid, which later was shown to be an essential metabolite of bacteria.

Since that time, Dr. Woolley and many others have found numerous instances of inhibitors of cellular reaction based on this form of interference, and the subject of antimetabolites must now be regarded as one of the fundamental hypotheses of biochemistry. It has shed light on living responses other than those of an enzymic and chemotherapeutic nature, such as hormonal interaction, pharmacological antagonism of drugs and vitamin deficiency diseases. Thus the close similarity between the structure of testosterone and œstrone suggests a basis for the well-known antagonism of androgens and œstrogens in higher animals, and for the regulation of sexual characters by a balanced reaction between these substances. In the sphere of vitamin activity, we find evidence of structural antagonism in the fact that typical signs of vitamin B_1 (aneurine) deficiency in mice can be called forth by pyrithiamine, and that glucoascorbic acid can elicit a condition in mice similar to that seen in scurvy in man. Dr. Woolley himself has been particularly interested in the pellagra-producing effect of maize; and, although he has not isolated the essential active antagonist to nicotinic acid, he has given reasons for believing that there is such a substance and that it may well be related to β-acetyl pyridine, which certainly is an antagonist to the antipellagra vitamin. It is to be hoped that this problem will prove more straightforward than that of the rachitogenic action of oatmeal, where it was found that the struggle for calcium by phytic acid and phosphoric acid was decided by the presence of vitamin D.

While Dr. Woolley has assembled the essential facts—up to 1950—which have poured as a stream into the crucible, and has described and discussed them in their proper place, he has emphasized throughout that the hypothesis will require modification as the subject develops. This critical and philosophic attitude, and the realization that the antimetabolite hypothesis is only serving as a support for the acquisition of new facts which will in time require new scaffolding is one of the many attractive features of the book. It is already clear that there are, at present, many inexplicable difficulties, and that some of the reactions described are undoubtedly more complicated than is now apparent; but the great merit of the theory is that it will continue to stimulate greatly the acquisition of new knowledge of biochemical reactions and, it is hoped, of biological processes themselves.

Now that Dr. Woolley has put his hand to this particular plough, we look to him not only to discover many new facts and the generalizations that may be necessary to account for them, but also to continue to enlighten and delight us with further editions of this book as the subject unfolds. Biochemists and biologists will undoubtedly take the opportunity of profiting by the book, and of appreciating the new vistas now opened up by this intellectually pleasing hypothesis so well presented as a complete story by Dr. Woolley.

E. Mellanby

A PHILOSOPHY OF MANAGEMENT

The Art of Administration

By Ordway Tead. Pp. xvii+223. (London: McGraw-Hill Publishing Co., Ltd., 1951.) 32*s*.

No reviewer could do better than echo Stuart Chase's commentary on Mr. Ordway Tead's latest publication: "this is a fine thoughtful book, obviously the climax of a lifetime of study, meditation and active participation in the art and science of administration". For more than a generation Mr. Tead has been high among the classical authors in the American literature of industrial management, interested primarily in its philosophical aspects and concerned always to urge the practical executives to be more alive to a depth of fundamental thought on which to rest their practice.

In this new study, Mr. Tead takes up again his favourite themes of the essentially human core of management and of its bearing on the everyday working of the principles of democracy. Here, he has always believed, lie the major problems of the twentieth century. Several chapters take up this theme from various points of view, examining not only the ways and means of getting "leadership in action" within a democratic framework, but also many of the difficulties to be encountered. Perhaps for the first time Mr. Tead is now willing to recognize that "in a democracy people have to be only as free as they want to be". Effective leadership is always the key to efficient action—and without any intention either of cynicism or of paradox, one may posit as the central principle of democracy the institution of the selected authority that can govern the many to the satisfaction of all. How this is done is the content of Chapter 9, "Administration as Democratic Leadership".

In the narrower context, Mr. Tead's thesis is admirably summed up in a passage in the foreword contributed by Mr. L. Appley, president of the American Management Association: "We, the contemporaries of the age", he writes, "are coming to realise that management is a career and that its effective exercise is based upon the understanding of human motivations, sensitivity to the means of sensing human responses, and skill in supplying human satisfactions". What is involved in such skills forms the main substance of this book—the skills of leadership, not peculiar to the industrial world, though the analysis is here carried out in relation to the management of industry. A most useful chapter is the one entitled "Human Nature in Action", revealing in a very practical way the raw material with which every executive at every level has to work. How the leader has to apply his skills to this material is fully studied and the lines of approach set out for his guidance. He is warned, in another valuable chapter, on "Personal Power and Authority in Administration", of the dangers and pitfalls that will beset him because of his own frail human make-up: "the exercise of personal power over or with others is one of the ways in which we get a sense of worthwhileness, of registering with others, of maximising our egos". This line of thought is profoundly reminiscent of Mary Follett twenty-five years ago.

This is not a text-book of management practice: it is more valuable than that, and more unusual. Its philosophical character may, perhaps, not make quite the strong appeal in Great Britain which the author has commanded in the United States, but its thought and teaching are of immense value to the immediate

needs of Britain. For British readers, the choice of title is unfortunate, for it will serve to revive a controversy that has latterly been laid to rest. The process that Mr. Tead has been studying is now almost universally called 'management' over here, and the protagonists of 'administration' are fast dwindling. Nor is there any more a divergence about 'art v. science': the process of management is now recognized as a skill that partakes of each. Mr. Tead would have served his cause the better by calling his book, say, "A Practical Man's Guide to Leadership".

E. F. L. Brech

ADVANCED TEXT-BOOK OF ORGANIC CHEMISTRY

Chemistry of Organic Compounds

By Prof. Carl R. Noller. Pp. ix+885. (Philadelphia and London: W. B. Saunders Co., 1951.) 35*s*.

SCHOLARSHIP, much teaching experience and an appreciation of the worth of organic chemistry have gone to the making of this book. Its author, professor of chemistry at Stanford University, sets out his subject-matter in forty-two chapters. Two of these are mainly devoted to theory; the rest, as well as the customary elementary matter, deal with more advanced topics, such as heterocyclic compounds, synthetic rubber, fluorinated aliphatic compounds, amino-acids, steroids, organic peroxides, and compounds of phosphorus, of silicon and of metals. The contents are intended for the first two years of a course for university students.

Prof. C. R. Noller is aware that the ever-increasing mass of facts of organic chemistry can be seen as an ordered array and intelligently studied only if a knowledge of the underlying physical principles and of modern ideas of molecular structure have been so mastered that they can be applied. He is likewise aware that many a student has not the mathematics at command necessary for the latter task: he therefore makes use of bold simplification. Thus, of the two approaches to the structure of a molecule, he prefers to begin with that of the molecular orbitals and to introduce these by the geometrical method popularized in Great Britain by Prof. C. A. Coulson. Simplification is also effectively used in Chapter 7, which is devoted to an exposition of reaction mechanism, a subject on which the author lays much emphasis because of its integrating value. Here, readers meet the brilliant teacher. First, he recalls the factors concerned with equilibrium; then by means of diagrams, logical argument and simple mathematics, he proceeds to explain the different mechanisms. Several illustrative examples both of ionic and of free radical mechanisms are discussed at considerable length. Once again Prof. Noller directs attention to the work of British chemists, singling out for mention C. K. Ingold and his collaborators and paying a special tribute to the late Prof. A. Lapworth. The theoretical principles established in these two chapters are extensively applied in the body of the book. Thus, the chapter on aromatic nitro compounds has several pages on the mechanism of substitution in the benzene nucleus and includes the modern theory of nitration.

The forty well-written chapters of descriptive matter abound with distinctive characteristics, but considerations of space permit the recording of only a few examples. For example, Chapter 17 gives a concise, but in itself complete, account of stereoisomerism and includes a masterly exposition of the determination of the configurations of the sugars, while Chapter 31, on dyes, opens with a discussion of the subject of colour and of its relation to chemical constitution.

An exceptionally full index (forty-five pages), historical footnotes, frequent and absorbing digressions on economic aspects, and devices to aid study (such as the use of two sizes of type and the numbering of the carbon atoms in big molecules) do not complete the list of attractive features. In short, this stimulating and inspiring book should afford the student just the help he needs. "Noller" will undoubtedly take a high place among the great instructional books of organic chemistry.

G. Fowles

POCKET ATLAS OF THE SWISS FLORA

Taschenatlas der Schweizer Flora

Mit Berücksichtigung der Ausländischen Nachbarschaft. Von Eduard Thommen. Zweite, vermehrte Auflage. Pp. xvi+309. (Basel: Verlag Birkhäuser, 1951.) 13.50 francs.

THIS booklet, of a convenient pocket size, contains more than three thousand black-and-white drawings of the ferns and flowering plants found in Switzerland and the adjacent areas of France and Germany. The drawings are carefully executed and reproduced; but their small size and the fact that they are rather crowded, with some dovetailing, makes it rather difficult to recognize all the species, even though detailed drawings of characteristic portions of flowers and fruits are given. The author himself considers that his drawings are best used in conjunction with one or other of the existing non-illustrated Floras of Switzerland. The fact that the present issue of the Pocket Atlas is a second and enlarged edition is proof that it has served a good purpose.

Below each row of drawings the author gives the Latin, German and French names of the plants, and he indicates by a small initial letter the colour of the flowers. In addition there are twenty-two pages in which some systematic, geographical or general information concerning many of the plants is given. The author generally informs his readers, when that is the case, that the plant to which he refers is not a native of Switzerland, but has become naturalized either by spreading by natural means from adjacent areas or by human agency. This latter will have been the case with such trees as *Catalpa* and *Paulownia*. It is a pity that in some instances no such information is given. Some readers may therefore not know that *Sarracenia purpurea*, which is figured, is a native of wet bogs in North America. It is not a Swiss plant, but may be found at least in one locality about 1,000 ft. above the Lake of Geneva, where it was planted many years ago and has since flourished. The author might also have mentioned the interesting fact that it is an insectivorous plant. But he has been rather chary about letting readers know that other plants like *Drosera*, *Pinguicula* and *Utricularia* are insectivorous. It is a pity that interesting information of this nature or of ecological facts is not given in the notes. It would be useful to reconsider this matter if a third edition is contemplated.

F. E. Weiss

SCIENCE AND AN EXPANDING AGRICULTURE*

By Sir WILLIAM SLATER, K.B.E.
Secretary of the Agricultural Research Council

WHEN the growth of a people has overtaken the supply of food and raw materials from the available land, they have either sought new land to exploit or by better farming produced more from that which they already had. This pattern of expanding agriculture has been continuously repeated throughout the history of civilization.

In England the earliest village communities based on the Saxon manor were self-supporting, the transport of heavy goods from one part of the country to another being almost impossible. As travel became more common in the fourteenth century, the wealthier people began to want luxuries from the Continent. To buy these goods, wool and woollen textiles produced from sheep grazing the English downlands were sent in exchange. So specialized farming began, and the system of exchanging the products of one type of farming for those of another was introduced. This trade greatly strengthened and enriched the life of the static farming communities.

By the seventeenth century the then known methods of expanding the production of food and raw materials were no longer sufficient to meet the demand, and science for the first time came to the aid of agriculture, by showing how more waste land could be brought into use and how the output of the existing farms could be further increased. The application by farmers of the knowledge which was being made available during this and the following centuries was slow, perhaps not surprisingly at a time when the old well-tried methods served to produce enough to give the farmer a satisfactory living. But whereas farming was prosperous, the production of food in Great Britain was not keeping pace with the needs of the now rapidly growing population in the industrial towns. So once more the common pattern adopted by a community in search of food was repeated. There seemed no immediate possibility of an increased yield from the acres of existing farm land, so attention was turned to finding new undeveloped land. Transport, already greatly improved and soon to be revolutionized by the steam engine, had made accessible the vast empty lands of the Americas, and of the southern hemisphere. It was to these lands the people of Britain turned for their food. First they began to grow wheat on the rich virgin soils, then to send their livestock to graze the native pasture.

The system of production used, which might be called static nomadism, had a number of characteristics worthy of note. First, no attempt was made to apply science in the utilization of the new lands, partly because the pioneers did not know what questions to ask; partly because the man of science could not have answered the questions which should have been asked without extensive research. Secondly, the food produced was cheap, being subsidized by continuous drawings on the capital reserves stored in the virgin lands and by the use of native labour. Cheap food, combined with intensive industrial specialization, resulted in cheap manufactured goods, which could be advantageously exchanged with other countries. Thirdly, this extremely advantageous economic system was entirely dependent on keeping transport moving freely; if it were interrupted the dense population must starve. Fourthly, the nation living in this way had to be powerful enough to prevent others encroaching on its food-supplying areas.

The United Kingdom exploited this way of living successfully for a hundred years; in the end too successfully. So great became the quantity of cheap food that it almost ruined our own farmers, while the capital assets in the virgin soils on which it drew were being rapidly exhausted.

When war partly blocked our transport lines during 1914–18, British agriculture had to try to fill the wide gap between our needs and our supplies. The farmers, who had changed their methods little in the past fifty years, set about their task not by trying to increase yields but primarily by bringing back into cultivation land which had been allowed to fall down to indifferent grass during the years of depression. For a short time farming was prosperous, but once ships began to move freely again the pressure of cheap food from overseas was too great to resist and the products of British farms were no longer wanted.

Science could claim little part in the food production campaign of 1914–18, but the study of agricultural science was greatly stimulated by the first danger of famine Great Britain had known for more than seventy years.

Before the First World War, a number of far-sighted men had pointed out that British agriculture, if it were to survive, must adopt new methods based on scientific knowledge, and that these could only be worked out in the laboratory and on the experimental farm. In 1909, research for the advancement of agriculture received its first direct State-aid through the Development Commission, and plans were laid for the expansion of the work at Rothamsted, Long Ashton, the universities and the agricultural colleges, and for the establishment of a number of new institutes. Under the stimulus created by the War, rapid progress was made, laboratories were built and equipped and young men recruited. Within a few years, however, depression hit not only agriculture but the whole country. The research institutes carried on with their work, but growth was halted and recruiting almost ceased for fifteen years. We are constantly reminded to-day of these blank years by the dearth of men in agricultural research between the ages of forty and fifty-five.

When a Second World War again disrupted our transport lines, this time more effectively than in 1917 and 1918, the farmers, with the help of the scientific workers, led a revolution in food production. Once more there was a great ploughing up of grassland, but it was accompanied this time by increases in the yield per acre and per beast. The joint efforts of farmers and men of science showed clearly that Britain need no longer depend on the continuous exploitation of virgin lands to meet our needs. We can produce on our farms at home, and in other lands settled by our own people, the food we want; but to do this we must develop research to the full and apply the findings vigorously in practice.

The value of research was recognized, and between 1944 and 1946 the late Sir John Fryer, the then secretary of the Agricultural Research Council, pre-

* Substance of an Evening Discourse delivered at the Belfast meeting of the British Association on September 8.

pared a plan for the development of research which was expected to be completed in ten years. This included the enlargement of existing institutes and the establishment of new ones in subjects for which facilities were not already provided. The plan has progressed, not altogether at the scheduled pace, but steadily and without serious omissions. Delays have not been due to lack of money, but to the shortage of trained men and the lack of buildings. We have learnt again that research cannot proceed in jerks, attempting to make up in a few years the neglect of many. If research is to be successfully developed, there must be a steady recruitment of scientific staff. Once it becomes known that men are no longer wanted for any particular type of work, entrants to the universities avoid training leading to it, and when recruitment begins again there are few applicants with suitable training. The flow of entrants to the universities starts afresh with the knowledge of available openings, but it is five or six years before these students are ready to take the most junior research posts. Now that the men who entered the universities after the War are available, the supply of man-power has improved and the chief difficulty rests in getting building work completed. There is, however, on every side goodwill towards the agricultural research service and great enthusiasm among the workers. With these assets the difficulties inherent in our present economic troubles can be overcome.

The need for the vigorous application of the results of research in farming has also been recognized by the setting up of a chain of experimental husbandry farms and horticultural stations, to apply the findings of the research institutes under different conditions of soil and climate, to carry out experiments affected by local conditions and to take the place occupied by the pilot plant in the chemical industry.

This general acceptance of the value of research work and the importance of the application of its results in agricultural practice is part of a great change in our national outlook, in that it is now generally accepted that our hope of survival as a nation depends on greater output from our farms. Not unnaturally, the bulk of the nation, who are neither farmers nor men of science, wish to know what is involved before they commit themselves to a programme designed to give a high output on existing farm-land and to render fertile and bring into full use land of low productivity. They may recognize that it is the only alternative to starvation, but still they rightly wish to know what is the cost.

Sir John Russell made a brilliant summary of the means by which food production can be raised in his presidential address to the British Association at its Newcastle meeting. Anyone hearing or reading that address must be convinced of our technical ability to achieve an enormous increase in food production. Sir John, however, added this warning: "If more food is needed, more work must be done to earn it". It is clear from the context that Sir John was referring not only to work on the land; he was also speaking of the work involved in producing the equipment and supplies needed for an expanding agriculture.

There is a true parallel between the great war-time projects and a major drive for increased food production. It may be suggested that in war there is the consciousness of immediate danger not present in time of peace acting as a spur to common effort and sacrifice; but famine, although it may be a less tangible enemy than an advancing army, is even more deadly and more ruthless. Again, it may be argued that war-time projects, often great in conception and large in scale, fire the imagination so that the most humble duty gains an added sense of importance and urgency, whereas agriculture, lacking these qualities, reduces all effort to the common daily round of work. This may have been partly true in times when farming methods were static, when tradition ruled over everything; it is certainly untrue of an expanding agriculture and of the scientific work which makes the expansion possible.

If we look at the work which is already being done and that which is projected in the British Isles and elsewhere throughout the Commonwealth, we find projects as large and as daring as anything attempted in war. Here are some examples.

The first is a story of land infertile due to lack of water turned into rich farm-lands by the irrigation engineers, and of their titanic scheme to change the course of a river and send part of its waters to double the irrigated area. The Great Dividing Range of mountains follows closely the east coast of the Australian continent, until reaching the extreme south it turns at right-angles to run due west. In the south-east, roughly where the range makes its sharp turn, the land rises to its greatest height in the Snowy Mountains of more than 7,000 ft. Here there is an area of 40 square miles with an altitude of more than 6,000 ft. and an annual rainfall at the highest points of more than 100 inches. From these snow-covered mountains rise the Murray River and its great tributary, the Murrumbidgee, to flow westwards through New South Wales and Victoria, behind and parallel to that part of the Great Divide that runs westward from the Snowy Mountain area. The moist winds from the sea leave most of their water on the slopes of the Great Divide, so that the country through which the Murray and the Murrumbidgee flow, on the landward side of the mountains, has a low rainfall of from 20 inches near the mountains to 10 inches farther inland. The soils of the river valleys are alluvial; much of the area is covered with good red-brown earths and other fertile soils, but without water they are of little agricultural value. Engineers, by building dams and cutting canals, have carried the water from the river to irrigate each year an area of more than a million acres—about twice the area of the county of Derry—of fertile land. From sparse grazing it is now producing milk, butter, beef, pork, fat lambs, fruit of all kinds, and rice. More dams and canals are under construction, which will irrigate further areas of equal size, making a total of land irrigated each year of more than two million acres. In addition, water for domestic purposes and stock is supplied to a much larger area. These extensions will have absorbed all the available water from these great rivers. No definite estimate has been made of the increased production which will follow the completion of this great network of irrigation, but on the basis of the output figures available for the present irrigation areas in Victoria, where 680,000 acres have yielded £15,000,000 worth of produce, it should be of the order of £40,000,000.

This is a large and ambitious scheme, and the Federal and State Governments might well have been content to rest on their laurels; but there will still be much good land left unwatered when every available acre/ft. of water has been taken from the Murray and the Murrumbidgee, so the engineers have considered another plan.

Rising in the same area as the Murray and the Murrumbidgee is the Snowy River; but it flows not west into the dry plain, but south through well-watered country to the sea. To the Australian, who is, over a large part of the continent, always fighting drought, this appeared grossly wasteful. If, he argued, this water flowed west into the Murray valley instead of south into the sea, then at least another million acres could be intensively irrigated. But a mountain range lay between the head waters of the Snowy River and those of the Murray and Murrumbidgee, so this seemed no more than an idle dream of what might have been, until the engineers and geologists got together and produced a scheme—now accepted by the Federal and State Governments—by which a large part of the waters of the Snowy River will be taken through two great tunnel systems under the mountain peaks and discharged on the western side into the Murray and the Murrumbidgee. The tunnel to the head waters of the Murrumbidgee will be 15 miles long, with a sectional area of 900 sq. ft. (the Simplon tunnel is 12·3 miles long), that to the Murray is to be in three sections, the first 8 miles long, with a sectional area of 700 sq. ft., the second 9½ miles long, with a sectional area of 1,150 sq. ft., and the third 4½ miles with a sectional area of 1,500 sq. ft. The cross-section of the tunnel is increased as it picks up water from other tributaries through vertical shafts. In addition to these main tunnels the scheme involves many subsidiary tunnels, seven great dams with storage capacity of more than 3,000,000 acre/ft. and more than 400 miles of race lines. Apart from its agricultural importance in making possible increased production of the order of £20,000,000 a year, the scheme provides for the generation by water-power of 2½ million kilowatts of electric power.

This surely is a project to fire the imagination and to call forth a great co-ordinated effort; it is as exciting as the original exploration of the Australian continent and calls for courage equal to that shown by the early explorers.

This, it is true, is only one scheme, large in scale and dramatic in its daring conception, but it illustrates well what the engineer is now doing in many parts of the world, and can do increasingly in the future, to bring water to arid but otherwise fertile land. The cost of irrigation may be high, but so also is the return.

There are deserts which do not lack water, but where the land is barren, due to the absence of one or more of the elements essential for plant or animal growth; the amount of the missing element required is often very small and large areas of land can be made fertile at relatively low cost.

In parts of Scotland and the south-western counties of England a nutritional disease of sheep has been recognized for more than a century. The name 'pine' describes the disease well; the young lambs gradually waste away and die. The only remedies known were to move the lambs to unaffected pasture or to bring soil from other districts and give it, mixed with water, as a drench. The same symptoms were observed in other parts of the world, particularly in Australia and New Zealand. It was thought the disease might be a form of anæmia, and ferrous sulphate was tried as a remedy with varying results. After further experiments, it was shown by Marston that the so-called 'coast disease' of the South Australian littoral, and by Underwood and Filmer that enzootic marasmus in Western Australia, responded dramatically to small doses of cobalt given by mouth. Animals could be kept healthy on the deficient pasture, and those already seriously affected responded rapidly on receiving doses of one milligram of cobalt a day. Other workers soon established that cobalt deficiency was responsible for pine in the Cheviots and many other parts of Scotland, while in England the same condition was proved to exist in Devon, Cornwall and Worcestershire. Bush sickness, which occurs on large stretches of the pumice soils of New Zealand, was also shown to be due to lack of cobalt. Salt sickness in Florida and nakuruitis in Kenya were later added to the list of diseases responding to treatment with cobalt. Marston, who has made an extensive study of this subject, has recently stated that there are probably many other parts of the world where animals are seriously affected by lack of cobalt and where its administration would produce the same striking results. Cobalt is not the only element having remarkable effects when applied to deficient soils in small quantities or when fed to stock grazing deficient herbage. Low concentrations of copper, molybdenum, boron, manganese, magnesium, zinc and sulphur have all been proved to be responsible for failures either in crops or in stock. Frequently the trouble arises from the lack of two of these elements, or from the excess or lack of one rendering another unavailable. All areas where the yields of crops and stock fall below those normally to be expected from the soil and climate must be regarded as probably deficient in some nutrient and examined in the hope that the cause of the lack of fertility can be found and set right.

There is often a complex relationship between soil, plant and stock which makes the problem difficult of solution. The area of South Australia in which 'coast disease' occurs consists of two soil types, the one composed of calcareous marine shell fragments, the other of siliceous sands. Sheep grazing on both these soil types responded to treatment with 1 mgm. of cobalt a day, but another syndrome then appeared which had been previously masked by the more immediate effects of the cobalt deficiency. This proved to be due to a lack of copper. When both cobalt and copper were administered the sheep grew satisfactorily and remained healthy.

The next problem was to get a sufficient growth of pasture and other crops to feed larger numbers of sheep. Applications of the normal fertilizer mixtures of phosphate, potash and nitrogen failed to produce good yields of cereals or to establish pastures of sown grasses and legumes. It was then found that on the calcareous soils the lack of growth of plants was also limited by the copper deficiency and that a dressing of 7 lb. an acre of copper sulphate enabled cereals, legumes and grasses to respond fully to dressings of the major plant nutrients.

The addition of copper to the siliceous sands did not, however, produce the same results, and it was only after further years of experiment that Marston completed his great work by showing the lack of plant growth on these soils was due to a deficiency of zinc. To drive through the untreated areas and then to come quite suddenly on the improved pasture is to know what the prophet meant when he spoke of the desert being made to "rejoice and blossom as the rose". Nothing could be more rewarding and exciting than the work of the farmers and scientific workers in converting these wastes into fertile lands. The total effect on food production cannot as yet be estimated; all we know is that it must be very

large, as the hundreds of square miles involved are suitably treated and divided into farms supplied with the necessary buildings and fences.

The samples so far given have been of bringing infertile land into use; but an equal, or possibly greater, contribution to our food supplies can be made by increasing production on existing farm lands. There are two ways of doing this: one by increasing yields, the other by preventing waste. It has often been pointed out that the average yields of crops in the United Kingdom are much below what the best farmers expect as their normal return. There has been since the beginning of the War a steady increase in the average yields of our crops; that of wheat, for example, has risen by approximately 10 per cent. This may seem in itself satisfactory, but it appears less so when the present average figures of about 20 cwt. per acre are compared with the 30 cwt. on light land and 40 cwt. on strong land obtained by many good farmers. The difference here also lies in the full application of scientific knowledge. High yields depend on the use of a variety bred and selected to suit the conditions of soil and climate, the application at the right time and in the right way of the amounts of the different fertilizers which have been shown by the soil chemists to give optimum yields, the proper cultivation of the soil and the effective control of pests and diseases.

These sound practices are, however, not fully effective if the soil is not at the same time kept at a high level of fertility. In the United Kingdom we have never entirely forgotten the teaching of our great farmers on the need for a sound rotation, including crops to be eaten by stock in the field; but we have found their precepts difficult to follow in the years of depression and of rising working costs. The hurdled flock and the bullock yard on which fertility was based have largely disappeared, and the arable land has been used to an increasing extent for cash crops. Increased use of fertilizers and improved methods of controlling weeds and diseases have counteracted the loss of yield that would have inevitably followed the resultant lowering of fertility.

In the years immediately before the War the agronomists, led by Stapledon, took up the old idea of the ley and developed it as a means of maintaining output under modern conditions, while at the same time building up the fertility of the soil. The replacement of permanent grass by well-grazed short-term leys of three to four years, covering every field on the farm in turn as part of the normal rotation, or where there was no permanent grass the introduction of a similar ley to replace the root break and the one-year ley in the old four-course rotation, is now well understood and generally accepted.

We do not know yet how great a revolution this modern system of ley farming has brought about; we expected an improvement due to the re-introduction of stock on the arable land, but the men of science themselves have been surprised at the results achieved and are now busily at work seeking the explanation of the unexpected success, in order to define the conditions under which the ley produces the maximum benefit.

It is known already that the more productive the ley and the heavier the stocking, the better the arable crops that follow; we know, too, that a ley should always be broken while it is highly productive and that the arable land should be re-sown to a ley while its fertility is still high. In this way the fertility of the land can be steadily raised and year by year the crop yields increased. We cannot say what the maximum yields will be; the time may come when a yield of two tons of wheat an acre may be regarded as the normal.

Our immediate tasks are to learn all we can about the beneficial effects of the ley on soil structure, and to get the knowledge of how to build up fertility and increase yields of crops widely known and used on British farms.

Ley farming must also find an increasing place throughout world agriculture. Land that has been continuously cropped must be rested under a sward grazed by animals, and the native pastures that carry few animals must be fertilized and sown to new grasses and legumes, if they are to make their full contribution to the world's larder. Each set of environmental conditions into which these methods are to be introduced needs careful scientific examination.

If we grow heavier crops we must protect them from pests and diseases. The loss of food due to the attacks of wild animals, insects and plant diseases is, we know, enormous. In a recently published book, "Untaken Harvest", George Ordish has summarized the existing information about crop losses. He reaches the conclusion for Great Britain that in the year 1947, after spending £10,000,000 on the control of insect pests and diseases, the losses from these sources were equivalent to £78,000,000, and expresses this graphically by saying that it is equivalent to 33,000 of our farms producing no crop, and 51,000 skilled farm workers achieving nothing with their labour. To this must be added the estimates for the damage caused by rabbits and rats. Rabbit damage in Great Britain has been estimated at £50,000,000 per annum, and that by rats at £40,000,000.

All these figures are estimates and the damage must vary from year to year, but it would be safe to assume the total damage to average more than £100,000,000 per annum. The chemists, entomologists and plant physiologists are waging a continuous war against these enemies and have won some remarkable successes since 1947, but there is still much to be done. It seems idle to begin to speak of food shortage while we are losing more than 5,000,000 tons of food each year, and not putting into the battle the effort we should have made to save so large an amount in war-time.

The proportional losses in other countries are as high. Ordish calculates that the losses in South Africa are equivalent to half a million acres, and the loss through fungus attacks on cereals in Australia as equal to the yield of more than 900,000 acres. The same picture can be found in every country, varying in type and extent, but everywhere representing a very considerable fraction, often as high as one-fifth of the potential output.

What has been said of increases in crop production and losses due to pests and diseases can be repeated for the animals on the farm. The output of milk, meat and eggs depends on good stock, the right management, and the control of disease. Figures given for possible improvement in the conversion of crops and grass into animal products are little more than inspired guesses. They all agree, however, in assessing the figures as very high. It would be conservative to estimate a 20 per cent increase in the output of animal products from the same amount of feeding stuffs if the level of production on all the farms in Great Britain could be raised to the level, not of the best, but of the good, by the application

of existing scientific knowledge. In few countries would the increase be less and in many countries it would be much higher.

These examples of what could be done to expand agricultural output by the application of science serve to show that the world's food production is far below the maximum.

The rapidly increasing human population presses hard on the heels of available food supplies, and if production remains static, famine is inevitable. The control of population will come with the spread of education, but it will be a slow process; in the meantime the number of people to be fed will continue to rise rapidly. We have in the expansion of production the only means to ward off this danger which threatens the whole world, and particularly dense centres of population such as the United Kingdom.

Increased food production will require great efforts, and for a time sacrifices. Now more than at any other time in the world's history is that increase needed. Have we as a nation, has the world as a whole, the faith and the courage to set aside from our available supplies of trained men and materials those needed for the scientific expansion of agriculture? On the answer to this question may rest the fate of mankind.

X-RAY SHADOW MICROSCOPY

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THE simplest way of making an enlarged picture of an object is to put it close to a point source of illumination and to receive its shadow image on a photographic emulsion at a distance. The magnification obtainable is limited only by practical considerations. The resolution is determined in the first place by the size of the source, and secondarily by Fresnel diffraction in the object and by the grain size of the emulsion. When X-rays are used as illumination, their short wave-length permits higher resolution than with visible light and penetration of objects optically opaque; differential absorption may also enable specific elements to be detected. Shadowgraphy with a point source of X-rays was first proposed by Sievert[1]; later von Ardenne[2] suggested using electron lenses to reduce the electron beam to the required minute spot, but he does not appear to have made any experimental investigations. Recent work has yielded enough evidence to judge the potential value of the method and the limits of its performance.

Microradiography with this method offers higher ultimate resolution than does the contact method, in which the object is placed against an emulsion at some distance from a source of normal size; the resolution is then limited primarily by the grain size of the emulsion and finally by the wave-length of light used in subsequent enlargement. A value of 1 μ has been obtained by Engstrom[3] using Lippmann emulsions, and Ehrenberg and Spear[4] claim rather better results. The shadow projection method, by contrast, is limited in resolution only by the size of electron spot which can be obtained, in the order of 100 A. The shadow method also has the advantage in resolution, and in simplicity, compared with the use of reflecting surfaces to make a true X-ray microscope[5,6], which theoretically can also exceed the optical limit but seems to be restricted by practical difficulties to some 2000 A.[7,8].

The attractions of the shadow method have been obscured by fears that a sufficiently small focal spot could not be obtained or that the available X-ray output from it would be so weak that exposure times would be impracticably long[9,10]. For this reason Marton[11] recently suggested using pulsed cold emission from a tungsten cathode. However, experiments over some years have shown that this limitation, although real, is not such as to prevent optical resolution being at least equalled; preliminary results of the shadow method were lately published showing a resolution of a few microns[12]. Attention to experimental details, and especially to the design of the magnetic lens used for producing the micro-source, has allowed the performance to be brought closer to that of optical techniques. A full account of the apparatus is in preparation, and a discussion of its application to the study of insect morphology will shortly appear elsewhere[13]. Here the general scope of the method and its future possibilities and limitations will be sketched.

The essential need in realizing the shadow principle is to make the utmost use of the X-rays generated in the target. This is achieved by using a tungsten foil as target, on one side of which is incident the electron beam, while the specimen is placed almost in contact with the far side, with the advantage that it is also in air. By using magnetic electron lenses a point focus less than 1 μ in diameter can be obtained, and the X-ray source will be of similar size if the foil itself is not thicker than this; 1-μ tungsten foil has been mostly used, but experiments have been made also with laminated foils.

The resulting resolution in the shadow image is determined by the size of source, so long as the effect of Fresnel diffraction is rendered negligible by bringing the object very close to the source. The recording emulsion is placed as near as possible, in the interest of short exposure, but must be far enough away for the inherent image detail to be larger than the grain size; the camera has usually been a few cm. long. With an object-target distance of less than 1 mm. an initial magnification approaching 100 × is not difficult to obtain. Fig. 1 shows a test micrograph of a silver grid of 1,500 meshes to the inch, having bars approximately 2 μ and 3 μ wide.

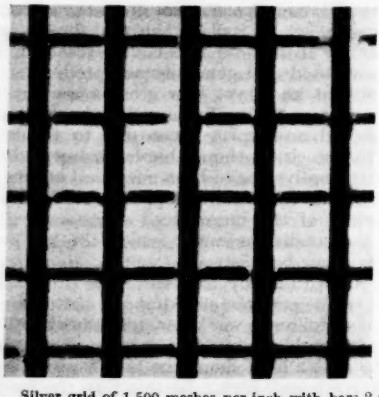

Fig. 1. Silver grid of 1,500 meshes per inch with bars 2 μ and 3 μ wide. Initial magnification × 100; total magnification × 700

The imperfections are rather less clear than in the best obtainable optical picture, and the resolution is estimated at about 0·5 μ.

The technique can be applied to any material containing inhomogeneities which cause differential absorption of X-rays, the wave-length being adjusted to give maximum contrast in combination with adequate penetration. For biological material, which has so far been the main subject, a long wave-length is required and a voltage of 10 kV. was chosen for preliminary studies; the minimum wave-length is then 1·2 A. with a peak intensity at about 2·5 A. Such a slow electron beam is readily focused by magnetic lenses, and a focal length of 1 mm. can be obtained with an excitation that does not call for cooling of the windings (2,000 amp. turns). A focal spot smaller than 1 μ can thus be obtained by imaging a tungsten filament with a single lens; a condenser lens has been added to control the illumination conveniently.

A typical micrograph obtained in these conditions is shown in Fig. 2, the fruit fly *Drosophila melanogaster*. By bringing the specimen closer to the target a higher primary magnification may be obtained at the cost of a reduced field of view; Fig. 3 shows an isolated head of the same insect. In each case the exposure time was 5 min.; a piece of 1,500 mesh grid serves as magnification and resolution standard. The specimens have been freeze-dried, since the high water content of the living insect obscures detail in the shadowgraph; some degree of drying is necessary for high resolution and contrast, and freeze-drying has proved to give least distortion of internal structure. Some work has been done on intermittent observation of living insects, immobilized for the period of exposure by anæsthesia. The poor resolution obtained may in some cases be more than compensated by the possibility of following internal processes, such as egg formation, in organisms opaque to light. The changes induced by high X-ray dosage may also be of interest; rough preliminary measurements show that the total dose received during photographic exposure is of the order of 100 r.

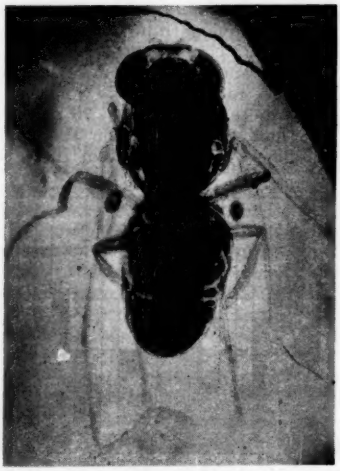

Fig. 2. *Drosophila melanogaster*, freeze-dried, with 1,500 mesh reference grid. Initial magnification × 20; total magnification × 30

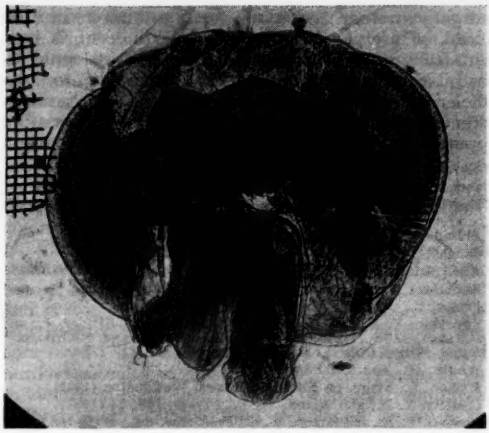

Fig. 3. Head of *Drosophila melanogaster*, freeze-dried, with 1,500 mesh reference grid. Initial magnification × 30; total magnification × 90

In its present form, with a resolution somewhat short of that of the optical microscope, the chief value of the method lies in the possibility of examining specimens normally opaque to light. It is also an advantage that stereographs can be obtained of equally high resolution, since the whole depth of specimen is in focus compared with the restricted focal depth of an optical microscope at high resolution. A stereo-view of a head of *Drosophila*, for example, shows the complex structure of the eye and brain in immediate three-dimensional perspective. The prospect appears of examining at high resolution much thicker sections of bulk tissue than can be tolerated in normal microscopy.

The main difficulty in the way of further development threatens to be that of electron intensity. It has long been known that the dissipation of energy from a focal spot becomes relatively more rapid as its diameter is reduced, and conditions are specially favourable in a laminar target where heat flow is almost entirely radial. Detailed investigation[14] shows that with a spot of the order of 1 μ, the temperature can be raised towards the melting point only by over-running the filament considerably compared with normal operating conditions. The limitation on exposure time with still smaller spots then resides in the filament rather than the target. An exposure time between 1 and 10 minutes has been found practicable with a spot of less than 1 μ, without seriously shortening the life of the filament.

The decreased X-ray output resulting from a further reduction in spot size to 0·1 μ could be partly offset by reduction in camera length and by further overrunning the filament, so that the exposure time need not be greatly increased. But the use of an electron spot of the order of 100 A., which can be obtained by two stages of demagnification of the beam, would seem to demand exposure times of the order of one hour. In any event, it is doubtful if many biological problems exist for which such a resolution would be useful, owing to the poor absorption of organic matter for X-rays; features 100 A. thick would only give sufficient contrast to be observed if very long wave-lengths were used, requiring a vacuum camera. However, loading of the specimen with heavy elements may be practicable, and there are problems of a metallurgical and

inorganic nature for which such a high resolution would be useful. Where the absorption of X-rays is much greater, a higher electron voltage could be used, with corresponding improvement in the efficiency of X-ray production. For the present, attention is being paid to refining the existing apparatus and exploring the range of its application.

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NEW EVIDENCE OF COMMUNICATION IN THE HONEYBEE COLONY*

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SCIENTIFIC interest in honeybees centres upon their most striking achievement—the organization of a social life. Social co-operation and coherence presuppose communication between the members. Part of the 'language' of bees has been studied and described by K. von Frisch[4–6], but his investigations were only concerned with recruitment to crops by successful foragers. There must also be other types of communication, concerned with co-ordinating the various activities within the colony, and there might be means by which members of a colony recognize each other.

G. A. Rösch[7] showed that marked workers in an observation hive undertook a sequence of tasks according to their age—brood-rearing, nectar ripening and storage, wax production and comb-building, and finally foraging. However, there is evidence that this succession need not apply in colonies with bees of abnormal age distribution[8,9].

Ribbands[1], who marked groups of workers which had all emerged into a colony on the same day, found that when they commenced their last task—foraging—their ages lay in the range 9–35 days. In addition, the expectation of foraging life of the last group of bees to commence this activity was substantially less than that of their comrades (Fig. 1), so that senility had played some part in their mortalities and they had commenced foraging at a more advanced 'physiological age'. In order to reduce the effects of changing weather conditions, means for three days

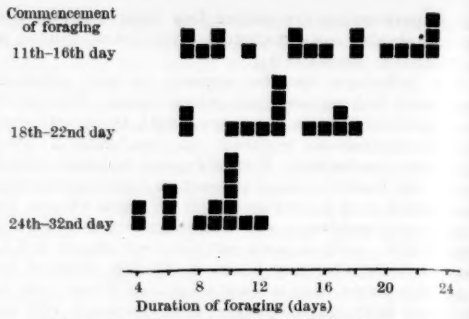

Fig. 1. Duration of foraging for individuals, exp. 1

running were applied to the data concerning the ages at which the bees commenced foraging; but despite the smoothing effect of this procedure, the distribution was markedly trimodal (Fig. 2); the peaks indicate that, even in this normal colony, most of the bees had skipped some of the duties in the sequence.

Thus Ribbands concluded that the age of the individuals was not the over-riding factor in determining the allocation of their duties, but that some other factor was more important. The main tasks of a colony are related to the food supply, which may determine the proportion of bees required for each task. It was thought possible that food supply also affected the metabolism of the individual workers and so led to an appropriate redistribution of their labour to the required proportions; evidence to support this hypothesis is detailed in the full paper[1].

It was supposed that, if food supply determined the allocation of duties, any change in the supply would be quickly appreciated throughout the colony. Investigating this possibility, Nixon and Ribbands[2] showed that there exists a rapid and extensive sharing of food between the members of a colony. In one experiment six foragers from a colony of 24,500 bees were marked and trained to a dish containing sugar syrup. This dish was then replaced by another one, which was filled with 20 ml. sugar syrup which contained 100 μC. of phosphorus-32, and in 3¼ hours the six marked foragers carried this solution into their colony. Two hours later, 70 foragers were collected from the hive entrance and 6–12 honey bees from each of the 33 combs in the hive. 62 per cent of these foragers and 19 per cent of the bees from the combs were radioactive. Twenty-four hours later, larger samples were taken; 76 per cent of the foragers and half of the bees on the combs were radioactive. The wings and legs of these bees were

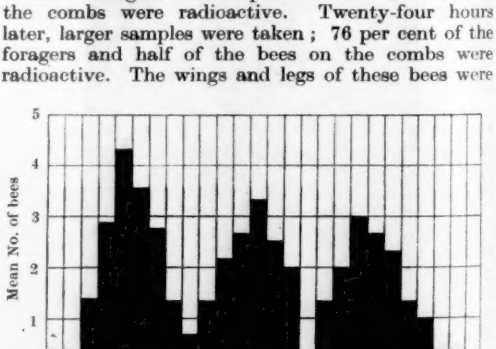

Fig. 2. Age at which foraging commenced, exp. 1. Three-day running means

* Summary of three papers (refs. 1–3) read before the Royal Society on June 19.

not radioactive, so that the transmission had not been caused by external contact, but by food intake. In addition, forty-eight hours after feeding the tracer syrup, 100 per cent of a sample of 85 of the older larvæ of the colony were radioactive.

This food sharing could provide a material basis for the known division of labour in the honeybee colony. Ribbands[1] supposes that at any particular time each task in the colony is undertaken by a group of bees which differ slightly in age; the main tasks involve food manipulation, and any surplus is appreciated by all members as a consequence of the widespread food transmission; the oldest bees of the group are then most likely to leave this activity and turn to whichever of the subsequent duties is most in need of recruits.

The results of the food-transmission experiments are complementary to the unexpected results of experiments concerning the odours by which honeybees recognize their companions[3]. Von Frisch and Rösch[10], who trained two colonies of honeybees to visit neighbouring dishes of syrup and noted that newcomers were preferentially attracted towards foragers from their own colony, thought that this preference was caused by a difference in odour. For a re-investigation of this problem, Kalmus and Ribbands[3] designed the following technique. Two Petri dishes, *a* and *b*, were placed about a yard apart about a hundred yards away from a pair of colonies *A* and *B*. A wooden screen was placed between the Petri dishes in order to facilitate the separation of odours emitted in their vicinity. One evening the entrance of colony *B* was closed, and the next morning dish *a* was filled with sugar syrup and a group of 50 foragers from colony *A* were trained to it. The thoraces of these bees were marked with white paint and any additional bees were killed. That evening the entrance of colony *B* was opened and that of colony *A* closed. Next day dish *a* remained empty, dish *b* was filled with sugar syrup, and 50 foragers from colony *B* were trained to dish *b*. The thoraces of these bees were marked with blue paint, and additional bees were again killed. The entrance of colony *A* was now opened, and dilute syrup was supplied at both dishes. Soon the marked bees from both colonies were foraging at their respective dishes. Concentrated syrup was then supplied at both dishes in order to encourage the recruitment of newcomers[11], which were marked on their abdomens with paint of the same colour as that on the thoraces of the bees trained to the dish which they were visiting. When sufficient recruits had been marked, the dishes were removed. That evening both hives were opened and all marked bees found were killed and recorded.

In experiments with different pairs of colonies, it was always found that 70 per cent or more of the recruits went to the dish being visited by guides from their own colony. These highly significant preferences confirmed the result of v. Frisch and Rösch.

Another experiment involved only one colony, from which a group of 50 bees were trained to one of the two dishes, and marked. New dishes, containing concentrated syrup, were then placed at both sites, and all recruits to either dish were killed and recorded. During the first two hours of observation, 45 recruits went to dish *a* visited by the trained bees, but only 3 went to the other dish, *b*. The dishes were then exchanged. During the next 15 minutes only one recruit arrived at dish *b*, which the trained bees were now visiting, but seven recruits went to dish *a*. Thus the recruits had not been attracted to their trained comrades, but to something pertaining to the dish which had been visited by them. This could only be an odour, presumably emitted from their abdominal scent gland[12]. Other observations indicated that this odour persisted for at least two hours.

Further experiments, using halves of recently split colonies and testing by the basic technique, showed that the distinctive odours could develop quickly and were thus not inherited. Then on September 20, 1951, when little natural forage was available, a colony was dequeened and divided into three nuclei, *D*, *E* and *F*, which were set out in a row ten yards apart. *F* was then fed with half a pound of heather honey and one tablespoonful of treacle, while *D* and *E* were not fed. Foragers were then trained and marked, and on September 29 *D* and *F* were compared. 43 correctly marked and 14 incorrectly marked recruits were found in *F*, and 11 correct and 6 incorrect ones in *D*; thus a highly significant difference ($P = 0{\cdot}006$) had developed between the foragers of these nuclei. On October 5 the two unfed nuclei, *D* and *E*, were compared. 22 correctly and 20 incorrectly marked newcomers were found in *D*, and 16 correct and 13 incorrect ones in *E*; this difference is not significant ($P = 0{\cdot}7$). On October 6 *E* and *F* were compared. In *F* there were 37 correct and 16 incorrect recruits, and in *E* there were 35 correct and 5 incorrect ones. This difference in visiting is highly significant ($P < 0{\cdot}001$). Thus it appeared that no significant difference had arisen between the two unfed nuclei, whereas the fed nucleus had developed a distinctive difference in relation to the other two as a consequence of the differential feeding.

Differences in olfactory attraction do not require absolute differences between the odours emitted; they could also arise from relative differences in the proportions of the same constituents. Thus one would expect that odours from bees of one colony would attract bees from other colonies but to a lesser degree, as the experiments demonstrated. The different mixtures of odours could be derived more or less directly from differences in the crops harvested by the colonies, and a very thorough and extensive food transmission could ensure that the diet of all the foragers of any colony was almost identical, so that at any one time they could all emit similar odorous waste products. Scouts from neighbouring hives may often find different crops, and the readiness with which successful foragers communicate the whereabouts of crops to recruits[13] would maintain this difference so that diets of nearby colonies were not identical; thus the foragers of neighbouring colonies would have different odours.

The foregoing results are relevant to other problems. It has been held[14] that some of the phenomena involved in colony robbing and in queen introduction were explicable in terms of distinctive colony odours; the more recent opinions[15,16] which have rejected this hypothesis may now need revision. An observation of Kalmus[17] concerning fighting between bees of two visibly different strains which were trained to the same dish of syrup can now be explained in terms of distinct colony odours. Food transmission may be an attribute of all social insects, and it would facilitate the rapid dispersal of insecticides[18,19] and drugs.

The results also pose the following new problems, which we are now investigating. Production of the distinctive colony odours suggests that food transmission is even more thorough than has now been

recorded, so that a detailed quantitative analysis is desirable. Perception of the distinctive odours suggests that honeybees possess a much more delicate capacity for distinguishing between different mixtures of odours than has been described[20]. It is certain that the most important function of the distinctive odours is facilitation of the social coherence and defence of the community.

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NEWS and VIEWS

British Association : President for 1953

The president-elect of the British Association for 1953, when the annual meeting will be held in Liverpool, is Sir Edward Appleton, principal and vice-chancellor of the University of Edinburgh since 1949. Sir Edward is well known among men of science both as an original investigator of outstanding ability and also as an administrator of scientific research. His fundamental work on the transmission of radio waves, carried out while he was Wheatstone professor of physics in the University of London (King's College) and later Jacksonian professor of natural philosophy in the University of Cambridge, received just acknowledgment by the award of the Nobel Prize for Physics in 1947. Then in 1939 he gave up the direct pursuit of research to become secretary of the Department of Scientific and Industrial Research, a post which he held for ten years—a period which saw the growth on an enormous scale of the participation of the State in fundamental scientific research and development. In all this activity Sir Edward was one of the leading figures, and his wisdom and characteristically gentle but persuasive drive enabled him to exert widespread influence. In 1949 came another change, when he went to the University of Edinburgh as principal and vice-chancellor, thus in a way completing his change-over to interest in administrative activities. Here he has already made his mark in the University, though he contrives to maintain his interest in his own special field of radio research. The British Association is fortunate in having so many-sided a man to guide it during the coming year.

Psychology at Manchester : Prof. T. H. Pear

Prof. T. H. Pear, who retired from the chair of psychology at Manchester in 1951, is to be succeeded by Dr. John Cohen, lately of Birkbeck College, London. Prof. Pear's tenure of his appointment has been of notable length, for it began in 1919, when a lectureship of which he had been the first occupant was upgraded. He had previously been a student at King's College, London, and at Würzburg and Giessen ; and, like that of many pioneers of psychology, his work was originally developed under the wing of philosophy with strong links with both physics and physiology. He has displayed great variety in his interests. From motion-study in coal-getting to the investigation of the expression of personality through the voice is a great jump, but Pear has been equal to it. In recent years he has focused his attention mainly on social psychological problems falling on the verge of social anthropology, and he has been particularly active in discussions on the social responsibilities of psychologists in the international field. He has been president of Section J (Psychology) of the British Association ; and of the British Psychological Society. He has also been Buchanan-Riddell Lecturer in the University of Durham. Of his dozen or so books, his first two, "Remembering and Forgetting" and "Skill in Work and Play", have been perhaps the most influential.

Prof. J. Cohen

Dr. John Cohen, who succeeds Prof. Pear, is also a London graduate. He was at University College for eight years, under Sir Cyril Burt, and wrote his Ph.D. thesis on the "Statistical Study of Physical and Mental Types". During the Second World War he was in the Cabinet Office and spent much of his time as joint secretary of the War Cabinet Committee on the Use of Psychologists and Psychiatrists in the Services. Later, as a member of the Working Party on the Recruitment and Training of Nurses, he stimulated considerable discussion by an outspoken and cogently expressed minority report. In 1948 he became lecturer in psychology at Leeds, and in 1949 he was appointed to the chair of psychology in the Hebrew University, Jerusalem. Prof. Cohen also is greatly interested in social psychology. He has carried out two investigations for Unesco, and has been closely associated with the World Federation for Mental Health since its inception. Another of his concerns is the experimental study of higher mental processes. Recently, in addition to lecturing at Birkbeck College, where his scholarliness and integrity have been greatly valued, he has been engaged on an inquiry for the Acton Society Trust on the effectiveness of working units in relation to their size. He has published papers in the *British Journal of Medical Psychology*, the *Journal of Mental Science*, the *Journal of General Psychology*, the *Eugenics Review*, *Psychiatry*, *Occupational Psychology* and the *British Medical Journal*.

Proposed British Agricultural History Society

In the spring of this year, a well-attended meeting was held to consider the formation of a British Agricultural History Society. At this meeting a small committee was formed to explore the possibilities. The committee's inquiries were met with a promising enthusiasm, and it has now been arranged to hold an inaugural meeting under the chairmanship of Sir James Scott Watson. The director of the Science Museum, South Kensington, S.W.7, has allowed this meeting to be held in the Lecture Theatre of the Museum on September 25, at 2.30 p.m. The scope of the proposed Society's labours is to cover agriculture in all its phases, human and technical. The social life of all classes of rural society from the earliest ages is one branch of the subject.

The development of the practice of farming in its technical and regional aspects is another. The history of plant and animal breeding, diseases and their control, and all branches of agricultural science will be included; for example, agricultural chemistry, soil science, entomology, mycology, engineering, building, land drainage, etc. If sufficient support is forthcoming, a periodical containing research papers on all these subjects will be published, annually or more frequently, according to the funds that become available. For the present, Mr. J. W. Y. Higgs, Museum of English Rural Life, Shinfield Road, Reading, is acting as honorary secretary, and inquiries may be addressed to him. All interested will be welcome at the meeting at the Science Museum.

"The Times Survey of British Aviation"

NOWADAYS there are great expectations for those who look forward to the annual display and exhibition which is organized at Farnborough by the Society of British Aircraft Constructors. The aeroplanes which have made news in the previous year, month or even week, are then on show and now, for the first time, there is *The Times* survey of the whole field published for the occasion (September 1. 1*s*.). This is a deserved honour since, at least qualitatively, aviation is now an important part of our national enterprise. The contributors number some of the most eminent men in the field; and alas, one of them, Mr. John Derry, who wrote an article on test-flying, lost his life through the break-up of a *DH* 110 during the display at Farnborough. Some of the photographs of new aeroplanes are spectacular and most are excellent. The survey catches something of the family spirit which is a part of the equipment of all those engaged in British aeronautics—from the industrial apprentice to the research scientific worker. From the general reader's point of view, it may be a pity that this spirit has here pushed critical analysis into a somewhat secondary position so that this issue tends to be a survey only. The problem of the supply of technical man-power, especially at high level, is scarcely considered. Incidentally, there is no mention of the rejuvenating effect of the departments of aeronautics in some of the university engineering schools in Britain. Despite the spectacular progress which has been so strikingly demonstrated, there is as yet insufficient application of scientific technology to some vital problems of design. Can the present organization of the aeronautical industry adapt itself to life in a peace-time economy?

Cacao Collecting Expedition in Colombia

A CACAO-COLLECTING expedition to Colombia has been organized by the Imperial College of Tropical Agriculture, Trinidad, and the Government of Colombia, and the advance party, consisting of F. W. Cope (plant breeder and expedition leader), R. E. D. Baker (plant pathologist) and D. J. Taylor (entomologist), has already commenced work in the forests. Further members are being sent out so that no worker will spend more than three months in the forest without a break. In addition to the British personnel, Colombian scientific workers will be participating in the expedition, and also Dr. R. E. Schultes, who has had much experience in the area collecting *Hevea* species for the United States Department of Agriculture. This expedition has been financed by the British West Indian and the British West African Cacao Research Scheme with the full co-operation of the Government of Colombia, and is expected to last for some twelve to fifteen months. The first area to be investigated is the River Apoporis, one of the upper tributaries of the Amazon; and subsequent trips are planned to the Rivers Cuaviare, Inirida, Vaupes, Caqueta and to the vicinity of the Casiquiare Bifurcation, the waterway linking the Amazon with the Orinoco. If time permits, short visits will also be made to cacao-growing areas of northern and western Colombia. The expedition plans to follow the main rivers, using aluminium canoes fitted with outboard motors, which can be transported from Bogota, the main base of operations, and from river to river, by Catalina aircraft. It is expected that, in addition to the rivers, it will be possible to use the trails made by the rubber-collectors, and that wild trees of *Theobroma cacao* and of other *Theobroma* and *Herrania* (a genus closely related to *Theobroma*) species will be found scattered or in small groups, but scarcely ever cultivated, throughout the area. The object is to explore the area, which is thought to be one of the homes of Criollo, or high-quality cacao, and thereby to obtain specimens which will widen the existing range of breeding material. Seed and budwood of cacao and of the related wild species will be sent by air to Trinidad and to the Colombian research station at Palmyra.

Progress in French Electronic Instrumentation

ISSUE No. 3, last year, of *Laboratoires*, the quarterly review, in French and English, of French technology, is devoted mainly to electronics and electronic instruments. The opening article is by Prof. P. Grivet who briefly reviews some of the modern applications of electronics. This is followed by a most interesting application of an electron probe and a new method of metallographic spot analysis which has been developed in the laboratories of the Office National d'Études et de Recherches Aéronautiques. If a substance is bombarded by a beam of electrons, X-ray emission is produced and the spectrum of the radiation contains lines which are characteristic of the chemical elements in the bombarded region. By use of electron lenses the beam can be focused and concentrated so that the bombarded region is of very small dimensions, of the order of one micron. An electron microscope has been modified so as to produce the probe, and some of the possibilities of the method and results of experimental tests performed with the apparatus are described. It would appear that the method is rapid and is capable of considerable accuracy. Other articles in the issue are on the mathematical basis of cybernetics, by R. Vallée, vice-president of the French Association of Electronic Engineers, and on the action of short-wave electromagnetic radiations on the maturing of wines, by Prof. M. Lafargue. Finally, there are two articles dealing with medical research: the first deals with electronics in cardiology and describes the various means and apparatus used for observation, analysis, treatment and control; and the second, by Prof. Ch. Oberling, director of the Institut de Recherches sur le Cancer, Villejuif, describes scientific cancer research, its method and tools, with illustrations and details of the particular work carried out at the Institute.

Fluorescent Lighting in Museums

AN article by M. J. Genard, of the University of Liège, originally published in *Museum* (**5**, No. 1, March 1952) was reprinted, with some additional material introducing the results of more recent

research, in the *Museums Journal* of April 1952. A short summary of the latter paper was published in *Nature* of August 23, p. 306. More recently in the *Museums Journal* (June 1952), Messrs. F. I. G. Rawlins (National Gallery) and W. E. Rawson-Bottom (Ministry of Works) have queried some of the statements made in the paper and consider that more specific data should have been obtained in some of the experiments. They have carried out some independent tests and clarified the position as it concerns the museum curator. Their conclusion is that the danger of fading to museum collections exposed to normal fluorescent lighting is negligible.

Rabbit Repellents : a Correction

A review of *Plant Pathology*, a new quarterly journal, appeared in *Nature* of June 21, p. 1050. One of the papers included in this first number concerned the results of trials by H. V. Thompson and C. J. Armour of rabbit repellents for use on fruit trees. The best of these was erroneously given as mixture 96*A*, whereas a mixture of 8 lb. resin in 1 gall. of denatured ethyl alcohol gave the best performance, with only 2 per cent of treated apple stocks showing severe damage.

Present Problems in Nutritional Research : Symposium in Basle

A symposium on "Present Problems in Nutritional Research" will be held in the Kollegienhaus, Petersplatz 1, Basle, during October 1–4 under the auspices of the International Union of Nutritional Sciences. The speakers and their topics will be as follows : Dr. J. Trémolières (Paris), choice of foods ; Prof. A. I. Virtanen (Helsinki), natural foodstuffs for nutrition ; Dr. D. P. Cuthbertson (Aberdeen), microbiology of digestion, with reference to farm animals ; Prof. E. Crasemann (Zurich), energetics of fodder and its metabolism ; Prof. E. J. Bigwood (Brussels), free and combined amino-acids in foodstuffs ; Prof. K. Lang (Mainz), deterioration of egg-white ; Prof. K. Bernhard (Basle), food factors in the prevention of liver-fattening deposits ; Prof. K. Thomas (Göttingen), feeding trials with synthetic fatty acids ; Prof. O. Högl (Berne), incorporation of additives in food ; Prof. E. Abramson (Tomteboda), food additives, including toxic substances ; Dr. S. J. Folley (Reading), hormones for nutrition ; Prof. A. B. L. Beznák (Birmingham), dietary fat, work and growth ; Dr. L. J. Harris (Cambridge), practical significance of vitamins ; Prof. H. Dam (Copenhagen), deficiency and mode of action of vitamin E ; Prof. H. D. Cremer (Mainz), minerals in foodstuffs ; Prof. V. Demole (Lausanne), fluorine and caries ; Dr. W. R. Aykroyd (Rome), nutrition work of F.A.O. ; Prof. A. G. van Veen (Rome), local foods in supplementary feeding schemes. Participation in the symposium is free. Further information is obtainable until September 30 from *Experientia*, Verlag Birkhäuser AG., Basel, Elisabethenstrasse 15, and after then from the Kollegienhaus, Petersplatz 1, Basel. The secretary of the International Union of Nutritional Sciences is Dr. Leslie J. Harris, Dunn Nutritional Laboratory, Cambridge.

North of England Institute of Mining and Mechanical Engineers

The centenary of the foundation of the North of England Institute of Mining and Mechanical Engineers is to be marked by a meeting during the week beginning September 22 in Newcastle upon Tyne. The meeting opens with a civic reception and luncheon, and includes a centenary dinner, at which the president of the Institute, Prof. Granville Poole, will present the Buddle Medal to Mr. Austin Kirkup, of the Durham Coal Owners' Association. Papers will be presented during the meeting on the development of the Tyne coal basin (Dr. A. Raistrick), coal miners' nystagmus in County Durham (Prof. R. C. Browne), lighting (Joint Lighting Research Subcommittee, King's College and the Institute), accidents from falls of ground (H. F. Wilson and H. J. Perrins, H.M. inspectors of mines), control of the strata in mining (Institute's sub-committee on the subject), pneumoconiosis in Durham and Northumberland (Dr. R. I. McCallum, Dr. E. N. Trounson), dust suppression (Dr. J. H. Jones), methane emission (A. B. Dawson), ventilation (Joint Ventilation Subcommittee, King's College and the Institute), and mechanization of coal mining in the north of England (J. S. Raine). Throughout the meeting there will be a mining exhibition in the University School of Mines, King's College, Newcastle upon Tyne.

Announcements

Lord Eustace Percy will be president of the Health Congress to be held at Hastings by the Royal Sanitary Institute during April 28–May 1, 1953.

The fourth post-war annual general meeting and symposium of the Deutsche Gesellschaft für Fettwissenschaft, Münster, will be held in Düsseldorf during October 6–10. The British representative is Dr. L. Ivanovszky, "Glenbrook", 68 Park Street, Bridgend, Glam.

The Autumn Meeting of the Institution of Naval Architects will be held in Italy during September 25–October 2, in collaboration with the Collegio degli Ingegneri Navali e Meccanici and the Associazione di Tecnica Navale. Meetings for discussion of papers will be held in Genoa (September 26) and Rome (September 29).

An international congress of therapeutics will be held in Madrid during October 16–18 under the presidency of Prof. T. Hernando. The programme will consist of three sections discussing, respectively, potassium, massive hormone-therapy and radioactive isotopes. Further information can be obtained from the III Congress Internacional de Teropéutica, Instituto de Farmacologia, Ciudad Universitaria, Madrid.

An all-day symposium on "Properties of Metallic Surfaces", arranged by the Institute of Metals, will be held in the Lecture Theatre of the Royal Institution, Albemarle Street, London, W.1, on November 19 (9.45 a.m.–5.0 p.m.). Attendance at the symposium is free to all who are interested on application to the Secretary of the Institute, 4 Grosvenor Gardens, London, S.W.1, from whom further information can be obtained.

The University of Padua is offering a Gabriella Zuccari scholarship of 250,000 lire during the academic year 1952–53 for research of at least six months duration at the Zoological Station, Naples. The scholarship is open to any person who wishes to undertake research in zoology, comparative anatomy, physiology or embryology, and it may be renewed up to a maximum of three years. Application forms (to be returned by October 31) and further information can be obtained from the Secretariat of the University of Padua.

SECOND INTERNATIONAL CONGRESS OF BIOCHEMISTRY

THE Second International Congress of Biochemistry was held in Paris at the Sorbonne during July 21–27 and was attended by some two thousand two hundred members from all parts of the world, including about four hundred from Great Britain. Although the large number of adherents proved a surprise and even an embarrassment to the organizers, the arrangements worked with a smoothness which revealed a vast amount of careful preliminary organization by the executive committee under the chairmanship of Prof. C. Fromageot, with Prof. J. E. Courtois as general secretary.

The opening session in the grand amphitheatre of the Sorbonne was attended, in the unavoidable absence of the President of the Republic, by the Minister for National Education, who brought the good wishes of the French Government. The meeting was also addressed by Prof. Gabriel Bertrand, honorary president, by Prof. René Fabre, president of the Congress, and by Prof. C. Fromageot.

Four general lectures were delivered to the congress as a whole: by Prof. J. N. Davidson (Great Britain) on "Nucleoproteins and Tissue Growth" (in English), by Academician A. Oparine (U.S.S.R.) on "Les changements de l'action enzymatique dans les cellules végétales sous l'influence des facteurs exterieurs" (in Russian), by Prof. S. Ochoa (United States) on "Fixation of CO_2 in Animals and Plants" (in English), and by Prof. K. U. Linderström-Lang (Denmark) on "Protéines et enzymes" (in French). It is proposed to publish these lectures in the near future.

The main part of the Congress was divided into seven symposia running simultaneously, at which the main papers were moderately comprehensive reviews of recent work given by invitation by recognized authorities on the subjects concerned. These symposia have been published and were available in printed form at the beginning of the Congress. The symposia were supplemented by short communications given by members of the Congress at large.

In symposium No. 1, for example, on the "Biochemistry of Hæmopoiesis", H. G. Wijmenga (Holland) and M. S. Shorb (United States) reviewed recent work on the chemistry and microbiological assay respectively of the cobalamins (the vitamin B_{12} group), while the role of folic acid and the citrovorum factor was dealt with by E. L. R. Stokstad (United States). A most useful review of the metabolism of metals in hæmopoiesis was given by S. Granick (United States), who, as might be expected, dealt chiefly with iron and the importance of ferritin in its absorption and utilization, but who included the parts played by copper, cobalt, molybdenum and zinc. This led naturally to the bone marrow (M. Errera, Belgium) and to the utilization of proteins in blood cell formation (A. Aschkenazy, France). A. Neuberger (Great Britain) surveyed the important recent work on the biogenesis of the hæmin pigments with particular reference to porphyrin formation and the porphyrias, while M. F. Perutz (Great Britain) covered the structure of hæmoglobin.

The complex subject of the "Biogenesis of Proteins" was discussed in symposium No. 2. It opened with a masterly account by J. S. Fruton (United States) of peptide bond synthesis, which was followed by a discussion of the molecular kinetics of proteolytic enzymes by H. Neurath (United States) and of the role of glutamine, asparagine and glutathione in biosynthesis, by H. Waelsch (United States). The general problem of enzymatic peptide synthesis was dealt with in some detail by H. Borsook (United States), while the more specialized aspects of the formation of specific proteins were discussed by other speakers—milk proteins by T. S. Work (Great Britain), serum proteins and antibodies by F. Haurowitz (United States), procollagens by V. N. Oriekhovitch (U.S.S.R.), *iso*hæmagglutinins by R. Wurmser (France), penicillinase by M. R. Pollock (Great Britain) and adaptive enzymes by J. Monod (France). The vexed question of the function of ribonucleic acid in protein synthesis was surveyed by H. Chantrenne (Belgium), and the curious phenomenon of long-range enzymatic action by A. Rothen (United States) and by J. Winter (France).

Perhaps the symposium which aroused the greatest general interest was No. 3, on the "Tricarboxylic Acid Cycle". H. A. Krebs (Great Britain) introduced the subject by discussing the place of the cycle in cell metabolism, and was followed by C. Martius (Germany) and S. Ochoa (United States), who concentrated on certain detailed aspects. In such a discussion as this it was natural that coenzyme A should be dealt with in detail. F. Lipmann (United States) gave a general survey of its importance and discussed in detail recent studies on the synthesis of acetyl-coenzyme A by way of the interaction of adenosine triphosphate, coenzyme A and acetate which has led to the discovery of coenzyme A-pyrophosphate. The importance of the cyclophorase system was fully reviewed by D. E. Green (United States). This paper and the following one by F. Leuthardt (Switzerland) emphasized the importance of the mitochondria in the internal economy of the cell both in relation to the process of oxidation and to the formation of urea by the linking of the arginine cycle with the metabolism of glutamate and malate.

The biochemical dissection of some steps in the tricarboxylic acid cycle by means of inhibitors, and in particular its specific inhibition by toxic fluoro-compounds, was described by Sir Rudolph Peters (Great Britain), while alternative pathways and variations in the cycle were discussed by E. S. Guzman Barron (United States). No discussion of the citric acid cycle would be complete without reference to its role in fatty acid oxidation, which was ably reviewed by F. L. Breusch (Turkey). The final paper in this symposium was by W. A. Engelhardt (U.S.S.R.) on the enzymology of myosin.

Symposium No. 4, on "Hormones related to Proteins", provided a more miscellaneous collection of material. S. J. Folley (Great Britain) discussed the hormonal control of the initiation and maintenance of lactation with special reference to the adrenal cortex and insulin. The opposing actions of these hormones was illustrated by the observation that the potentiating effect of insulin on lipogenesis from small molecules could be diminished or abolished by cortisone. F. Sanger (Great Britain) reviewed his recent important work on the structure of insulin, for which the complete amino-acid sequences of fractions *A* and *B* are now available. *nor*Adrenaline was discussed by U. S. von Euler (Sweden), and the biologically important amines by Z. M. Bacq (Bel-

gium). The recent work of the Cambridge school on the metabolic influence of the pituitary growth hormone was ably surveyed by F. G. Young (Great Britain). R. Michel (France), in a remarkably thorough survey of the thyroid hormone, discussed the biogenesis of thyroxine, the formation and proteolysis of thyroglobulin and the nature of the circulating hormone.

It was not surprising to find that the fifth symposium, on the "Metabolism of Micro-organisms", was also very varied in content. E. Chargaff (United States) discussed the nucleic acids of micro-organisms, a subject which was also touched on by D. D. Woods (Great Britain) in his paper on the formation of folic acid and related growth factors. The surprising versatility of the various active forms of vitamin B_6 in enzymic reactions was clearly brought out by E. E. Snell (United States), while the lipids of the mycobacteria were reviewed in a comprehensive fashion by E. Lederer (France). Three papers dealt with the formation and metabolism of aromatic compounds. B. E. Davis (United States) and G. Ehrensvärd (Sweden) gave stimulating reviews of the biosynthesis of aromatic rings, and R. G. Stanier (United States) dealt with their oxidation.

The metabolism of micro-organisms featured prominently also in symposium No. 6, on the "Mode of Action of Antibiotics". W. W. Umbreit (United States) explained that streptomycin inhibited a reaction between oxalacetate and pyruvate which is lost in resistant cells. Both E. F. Gale (Great Britain) and F. Gros (France) emphasized the profound changes in nucleic acid metabolism and in protein metabolism (particularly the blocking of the uptake of glutamic acid) which take place in micro-organisms treated with penicillin. *Staphylococcus aureus*, for example, grown in presence of penicillin, produces derivatives of uridine-5′-pyrophosphate which were described by J. T. Park (United States). Discussion of the mode of action of antibiotics led naturally to the question of resistance, the genetic aspects of which were dealt with by L. L. Cavalli (Italy). R. D. Hotchkiss (United States) described how penicillin-sensitive rough-strain pneumococci give rise to a proportion of penicillin-resistant variants when grown in the presence of the deoxyribonucleic acid prepared from rough strains selected for spontaneously arising penicillin resistance. Finally, S. Americano-Freire (Brazil) gave an extensive account of the antibiotic properties of *p*-amino salicylic acid and its phenyl ester in experimental tuberculosis.

The seventh and last symposium dealt with "Steroids". The question of the relationship between chemical structure and biological activity was discussed for steroids in general by C. W. Shoppee (Great Britain) and for their 6-hydroxy derivatives by M. R. Ehrenstein (United States). G. Pincus (United States) dealt all too briefly with his recent fascinating work on steroid biosynthesis in the isolated perfused adrenal gland while W. Dirscherl (Germany) surveyed the effects of steroids on enzymatic reactions and metabolic processes. The urinary excretion of steroids and its clinical significance was discussed by E. R. Venning (Canada), G. F. Marrian (Great Britain), L. G. Huis in't Veld (Holland) and M. F. Jayle (France).

It was, of course, clear to the organizers of the Congress that all the original papers submitted by members could not be incorporated into the framework of the seven symposia. Such communications were therefore given in the most appropriate of the thirty-one different sections, which met in the afternoons and covered the following fields of biochemistry: (1) mineral elements; (2) lipids; (3) amino-acids and proteins; (4) nucleoproteins; (5) pigments; (6) fat-soluble vitamins; (7) water-soluble vitamins; (8) enzymes and coenzymes; (9) carbohydrases; (10) esterases; (11) phosphatases and depolymerases; (12) proteases; (3) oxidases and dehydrogenases; (14) carbohydrate metabolism; (15) amino-acid metabolism; (16) sulphur metabolism; (17) fermentations; (18) plant chemistry; (19) plant metabolism; (20) photosynthesis; (21) nutrition; (22) biochemistry of ossification; (23) clinical chemistry; (24) immunochemistry; (25) blood clotting; (26) muscle biochemistry; (27) physiological chemistry and pharmacodynamics; (28) chemotherapy; (29) biochemical effects of ultrasonics; (30) chemistry of cancer; (31) apparatus and techniques.

The lighter side of the Congress involved a large number of social functions, including a special performance of ballet at the Théatre National de l'Opéra and a whole-day excursion to Chantilly and Compiègne.

At the closing session of the Congress, with Prof. Fabre presiding, Prof. J. N. Davidson, who was deputizing for Sir Charles Harington as chairman of the International Committee, announced that an invitation had been received to hold the Third International Congress of Biochemistry in Brussels in 1955. Expressions of appreciation of the work of the French organizers were given formally by Prof. A. Tiselius (Sweden), Sir Rudolph Peters (Great Britain), Academician A. Oparine (U.S.S.R.), Prof. S. Ochoa (United States) and Prof. E. J. Bigwood (Belgium).

SOCIETY FOR APPLIED BACTERIOLOGY

SUMMER CONFERENCE IN CAMBRIDGE

THE summer conference of the Society for Applied Bacteriology was held during July 22–24 in Newnham College, Cambridge, and included a symposium, sessions for reading papers and visits to places of interest. At the annual general meeting, Dr. J. G. Davis (London) was elected president for the ensuing two years. The secretary of the Society, from whom further information can be obtained, is G. Sykes, of Boots Pure Drug Co., Ltd., Nottingham.

The symposium, to which contributions were made by H. B. Hawley (Yeovil), M. Ingram (Cambridge), R. S. Hannan (Cambridge), A. Hirsch (Bedford), N. R. Knowles (Belfast), and Miss M. P. Scarr (Bromley), was on "Aspects of Food Preservation". In introducing the subject Mr. Hawley described the origin and some of the earlier methods of food preservation and then, having outlined the principles required, gave some of the modern chemical, physical and biological methods in use. Dr. Ingram discussed the possibility of sterilization by high-frequency voltage fields using a voltage gradient of 1,000 V./cm. Heating during treatment is a major problem, and special precautions and apparatus have to be used to keep the test material cool. He described various types of apparatus and pulsation treatments employed experimentally, and

has found that, when temperature effects are eliminated, there is no evidence of significant lethal action on yeast cells, *Bacterium coli* or on bacteriophage. Earlier reports on the apparent success of the treatment must be attributed to heating effects. Dr. Hannan described sterilization experiments with high-energy electrons using an electron accelerator giving 0·1–15 MeV. or using gamma-rays from cobalt-60 with energies of 0·7 and 1·2 MeV. By irradiation from two sides the electrons can penetrate uniformly and effectively up to 10 cm. depth and the gamma-rays rather more deeply. Certain deleterious side-effects can be avoided by pre-freezing. Opinions are not in entire agreement on the actual lethal doses for micro-organisms, but in general $0{\cdot}2 \times 10^6$ roentgens kill vegetative bacterial cells, and $0{\cdot}5–2 \times 10^6$ r. bacterial spores; bacteriophage is more resistant than bacterial cells or enzymes. The dose required to kill is dependent on a number of factors, including the suspension medium and oxygen tension. The system appears to be economically possible and would have wide applications in the pharmaceutical field. In his paper on "Antibiotics in Food Preservation", Dr. Hirsch said that, in general, antibiotics have been used experimentally for the preservation of certain non-acid foods, the main organism to be dealt with being *Cl. botulinum*. Subtilin is of some value with canned peas, but in general the method does not appear to be practicable. Nisin has been used in cheese to prevent growth of *Clostridium* species (mainly *Cl. butyricum*); this antibiotic appears to be more effective in inhibiting germination of spores than development of vegetative cells.

Describing his observations on "The Microbiology of Raw and Heat-treated Liquid Egg", Mr. Knowles said that fresh-laid eggs are practically sterile internally, but low-grade eggs may contain many millions of bacteria per gram. On hard freezing, the viable bacterial population may be reduced by up to 55 per cent. Duck eggs are generally more heavily contaminated, carrying, in particular, Salmonella bacteria. By careful organoleptic control, the quality of raw hen eggs used for liquid egg preparation has recently been improved so that bacterial counts have been much reduced, and a suggested standard of less than 5×10^6 viable bacteria per gm. would be meritorious. Heat treatment is carried out at 149–150° F. (65–65·5° C.) for three minutes in a modified plate pasteurizing plant. This reduces the bacterial count to less than 1,000/gm., but careful control is necessary to reduce coagulation deposits on the plates. Miss Scarr, in her paper on "The Microbiology of Sugar-preserved Foods", dealt particularly with the properties of osmophilic yeasts and moulds, and discussed the types usually found as contaminants and their adaptability. Spoilage occurs either through growth of these resistant organisms or from local dilution of syrups brought about by condensation in the surface.

Papers given at other sessions included three on the detection and classification of organisms of the coli-aerogenes group. The first, by N. P. Burman and C. W. Oliver (London), showed that Folpmer's glutamic acid medium is somewhat superior to MacConkey medium in detecting *Bact. coli* in water; another by T. Richards and M. T. A. Fouad (Reading) discussed the use of inorganic media containing glucose in the classification of the group, and a third, by S. B. Thomas and colleagues (National Agricultural Advisory Service), reviewed the significance of the coli-aerogenes and *Bact. coli* assessments from more than 2,500 samples of farm waters. W. A. Hoy and L. F. L. Clegg (Shinfield) described a new test for dairy disinfectants using aged milk in soiled churns. Results obtained suggest that they might parallel those from longer-termed field trials. Miss C. Higginbottom and D. W. F. Wheater (Hannah Dairy Research Institute) discussed the occurrence of *Streptococcus bovis* in rumen contents, showing that there is a significant increase during the first hour after feeding; Mrs. A. C. Stirling (Edinburgh) indicated the importance of lactobacilli in silage to ensure a rapid fall in *p*H value and so reduce nutritional losses.

From the public health aspect, A. Clarenburg (Utrecht) discussed the occurrence of Salmonella bacteria in meat. Outbreaks of poisoning from this source are usually traced to meat products rather than raw meats, and carrier animals increase the complications. E. B. Reid and M. Woodbine (Aberdeen) demonstrated the 'Pressfish' process for preparing vacuum-dehydrated foods and discussed the microbiology concerned, and a paper by S. E. Jacobs and Miss M. J. Thornley (Ambleside), on the effect of ultrasonic waves on bacteria suspended in milk, showed that treatment at 20 kW. or at 1 Mw. is only partially lethal to a variety of bacteria, increased protection apparently being afforded by the high protein content. A. M. Paton and T. Gibson (Edinburgh) described an improved technique for assessing microbiological lipase activity, and Miss J. P. Cowne and J. R. Postgate (Teddington) an improved medium for estimating sulphate-reducing bacteria by dilution counts. The normal medium is supplemented with sodium sulphide and cysteine or ascorbic acid, rendering sulphate-reducers easily detectable by the precipitation of black ferrous sulphide.

INSTITUTE OF PHYSICS

ANNUAL GENERAL MEETING

At the thirty-second annual general meeting of the Institute of Physics, held on June 5 at the Institute's House, 47 Belgrave Square, London, S.W.1, the following were elected to take office on October 1: *President*, Dr. C. Sykes; *Vice-Presidents*, Mr. O. W. Humphreys and Dr. T. L. Ibbs; *Honorary Treasurer*, Dr. S. Whitehead; *Honorary Secretary*, Dr. B. P. Dudding; *New Ordinary Members of the Board*, Mr. H. Barrell, Dr. N. A. De Bruyne, Dr. W. H. Taylor and Mr. R. G. Wood. Prof. W. E. Curtis and Dr. F. C. Toy (past-presidents), Prof. E. G. Cox and Dr. J. Topping (vice-presidents), Mr. T. C. Keeley, Mr. G. R. Noakes, Dr. H. L. Penman and Prof. S. H. Piper continue to serve on the Board. Sir Owen W. Richardson was elected to honorary fellowship of the Institute.

The thirty-second annual report of the Board, covering the work of the Institute during 1951, was adopted at the meeting. It records that the Board met six times, and its various standing committees nineteen times, during the year. The membership increased by 222 to 4,080. Applications for election or transfer to the various grades of membership of the Institute received during 1951 numbered 524, compared with 627 in the previous year. There was a slight decrease in the number of subscribers and

students, but substantial increases in the numbers in the other grades, particularly in the recently established grade of graduateship. The regulations and syllabuses for the graduateship examination which were published during the year aroused wide interest, and the number of candidates for the first graduateship examination, held recently, was greater than was anticipated. The regulations governing election to the associateship grade were modified to permit the admission of candidates whose training in physics is adequate but who may have graduated in subjects other than physics.

The number of candidates who presented themselves for the 1951 examination for National Certificates in Applied Physics was substantially greater than in the previous year; twelve colleges entered candidates at the ordinary level and five at the higher stage. Nine technical colleges which have applied for recognition, or for an extension of recognition, as institutions approved by the Institute for the education and training of physicists, were inspected.

In 1949 the Board decided that the Institute should rapidly increase the volume of its publications, and although this development has been somewhat restricted by printing and other delays and the substantial rise in the cost of printing and paper, it has largely been implemented. In addition to its two journals, the *Journal of Scientific Instruments* and the *British Journal of Applied Physics*, and its monthly *Bulletin* to members, two further monographs in the "Physics in Industry" series were published. Other books published for the Institute (issued by Edward Arnold and Co.) were "Some Aspects of Fluid Flow" containing the papers presented at a conference organized by the Institute in October 1950; "Bibliography on Electron Microscopy", edited by Dr. V. E. Cosslett for the Institute's Electron Microscopy Group; and a further selection of laboratory and workshop notes from the *Journal of Scientific Instruments*, prepared and edited by Dr. Ruth Lang. A new development is the Board's decision to sponsor a series of small books suitable for university students and those studying for Higher National Certificates in Applied Physics, each of which will cover some branch of applied physics and be written by an authority in that field. It is hoped to launch the series shortly.

In addition to individual inquiries from members concerning professional matters, the Board has considered the Ministry of Labour's report on the supply of and demand for physicists, the right of travel for men of science and the part-time employment of retired members; and it has issued an informative report on the second survey of salaries and emoluments paid to fellows and associates of the Institute resident in Great Britain and Ireland. The Institute is represented on the Parliamentary and Scientific Committee and the Joint Council of Professional Scientists, and thus keeps in close touch with science in the government service and ensures that proper regard is given to the scientific point of view in the political sphere.

The fifteen local branches and specialist subject groups of the Institute held more than a hundred meetings during the year. Details of the various activities of the branches and groups are listed in the report. A new event was the very successful exhibition of scientific instruments and apparatus arranged by the Australian Branch in Melbourne, which attracted some four thousand visitors during the four days it was open to the public. The Branch committee has given consideration to a proposal that an independent Australian Institute of Physics be established, and the Board of the Institute has intimated that, if this proposal should receive the support of the Australian members, it would welcome the development. The London and Home Counties Branch, under the chairmanship of Dr. A. J. Maddock, held a summer meeting at the Cavendish Laboratory, Cambridge, and an 'at home' at the Institute's House in October. The Education Group held meetings in Birmingham (in conjunction with the Midland Branch) and Manchester (with the Manchester and District Branch), together with a joint meeting at Cambridge with the Electronics Group, and a three-day conference in London; it also visited the Royal Naval College, Greenwich. The X-Ray Analysis Group held its usual two conferences, has continued its work on the extension of data for the card index of diffraction data published by the American Society for Testing Materials, and has published a memorandum on the preparation and mounting of polycrystalline specimens for X-ray analysis. It is interesting to note that the National Committee of Crystallography, on which the Board is represented, has directed the attention of the X-Ray Analysis Group to the fact that the fortieth anniversary of the discovery of X-ray diffraction falls in 1952. It has since been announced that a commemorative meeting will be held during October 24–25 at the Royal Institution (see *Nature*, June 7, p. 949).

COST OF GERMAN MEDICAL AND SCIENTIFIC PERIODICALS

By Dr. W. BONSER
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AND
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THE exorbitant cost of German medical and scientific periodicals has once again become the concern of those who budget for university and other learned libraries. The cost of English periodicals has continued to rise, although slightly, owing to increased cost of publication; still more has the cost of American periodicals risen, not only on account of devaluation but also on account of similar production increases in the United States as well. But the cost of German periodicals has exceeded those to an alarming extent, and appears to be settling down at a figure which will make it impossible for many British libraries to continue their subscriptions.

A parallel situation arose after the First World War, and a united effort by those affected—conducted in the pages of *Nature*—succeeded in achieving a reduction of 20 per cent in 1933 and a further reduction of 25 per cent in 1935, conceded after a fall in value of the pound sterling. The pre-war complaints were not only of the excessive cost compared with that of British periodicals of a similar nature and size, but also of the impossibility of computing the annual cost, owing to irregularity in the number of volumes per year. This same state of affairs regrettably still obtains.

An analysis of costs of a selection of representative medical journals in similar subjects from Great

Britain, the United States, other European countries, and Germany (for example, *Journal of Physiology*, *American Journal of Physiology*, *Archives internationales de Physiologie*, *Pflügers Archiv*) has been made for the years 1938–39, 1950 and 1951, and shows that in these last two years the cost of German journals exceeded the combined sum expended on the others, although the increase on account of devaluation of sterling amounted to 45 per cent for American, and 26 per cent only for German periodicals. Compared with 1933, the totalled prices of the sets of journals in the four categories, taking the average of 1950 and 1951 in each case, may be presented in simple ratio as follows :

	British	American	Other countries	Germany
1933	1·0	1·06	0·875	3·8
1950–51 (averaged)	1·0	1·69	0·96	4·15

showing that the case for a reduction in price of German periodicals holds again.

A further table has been compiled showing that of these German periodicals from different publishing houses, those emanating from the Springer Verlag are three (3·2) times the cost of the others, and although the 1951 figures for Springer publications show a reduction on 1950 prices, the fall would appear to be due not to a reduction in price but to one in output.

We are told by experts that the post-war value of German scientific and medical periodicals is scarcely yet up to pre-war standard, but is still of high enough quality to justify their purchase by those who can afford them. It is obvious that German scientists will do their utmost to achieve the highest standard, and we are assured that they are prepared to co-operate in this effort to reduce the excessive price of their journals. We are sure it will be agreed that their output is as essential to research as that of other countries, and curtailment of its circulation owing to prohibitive costs is to be deplored. American librarians are equally anxious to find a solution to this problem, as has been evidenced in our correspondence with them.

It is impossible to print here the full text of this investigation, done in 1950 and revised for 1951 ; but a copy will be sent on request to those interested.

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FUNDAMENTAL PARTICLES

SCIENCE PROGRESS of April (**40**, No. 158, 193 ; 1952) contains an interesting and informative article by Prof. H. S. W. Massey entitled "Fundamental Particles", the term which is applied usually to such entities as electrons, protons, etc. Prof. Massey points out, however, that the quantum theoretical description of the physical world is a dualistic one in which mechanical phenomena are viewed from both a particle and a wave aspect and that classical physics is the limiting case when h, Planck's constant, tends to zero. It is better, therefore, when describing the fundamental nature of matter and radiation to begin with the purely wave description and then, by imposing quantization, to lead to the particle aspect.

It is Prof. Massey's contention that the general features and consequences of the application of quantum theory to wave fields can be made clear without the use of elaborate mathematics and can be appreciated without a detailed knowledge of physics, and after reading his admirable article the reader will doubtless agree with Prof. Massey. The quantized electromagnetic field and its associated particles, the photons, are dealt with first, then the electron field and finally the interaction between the two fields. It is shown that at no stage is it necessary to postulate action at a distance, but that the necessary interaction between particles can be transmitted through the electromagnetic field vacuum photons.

Turning next to the subject of the classification of the fundamental wave particles, Prof. Massey shows that the particles can be loosely separated into three categories, which he aptly terms "building stones" (electron, proton and neutron), "cements" (photon and pi-meson) and "bric-a-brac" (neutrino, mu-, V-, tau- and kappa-mesons). The first two categories, as their names imply, are involved in the structure of matter, but the third, apparently, does not fulfil any important role in that respect. The properties of the various particles and the relations between them are briefly and clearly described, and it is evident that their number (now some twenty-four) is far too large for them all to be fundamental. Nevertheless, as Prof. Massey states, the discovery of new particles is still a prominent feature of modern physics, and thus, until some new fundamental advance or simplification is made on the theoretical side, not only to provide a basis for the "bric-a-brac" but possibly also to account for the more complete range of particles yet to be explored, the fundamental scheme of Nature must remain obscure. S. WEINTROUB

DATING THE LIBYAN DESERT SILICA-GLASS

By DR. KENNETH P. OAKLEY
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PIECES of natural silica-glass up to 16 lb. in weight occur scattered sparsely in an oval area measuring 130 km. north to south and 53 km. from east to west, in the Sand Sea of the Libyan Desert. This remarkable material, which is almost pure (97 per cent SiO_2), relatively light (sp. gr. 2·21), clear and yellowish-green in colour, has the qualities of a gemstone. It was discovered by the Egyptian Survey Expedition under Mr. P. A. Clayton in 1932, and was thoroughly investigated by Dr. L. J. Spencer, who joined a special expedition of the Survey for this purpose in 1934.

The pieces are found in sand-free corridors between north–south dune ridges, about 100 m. high and 2–5 km. apart. These corridors or 'streets' have a rubbly surface, rather like that of a 'speedway' track, formed by angular gravel and red loamy weathering debris overlying Nubian Sandstone. The pieces of glass lie on this surface or partly embedded in it. Only a few small fragments were found below the surface, and none deeper than about 1 metre. All the pieces on the surface have been pitted or smoothed by sand-blast. The distribution of the glass is patchy

Drawn by C. O. Waterhouse.

PROBABLE ATERIAN ARTEFACTS FROM LIBYAN SAND SEA

(1) Miniature foliate 'hand-axe' in silica-glass; plano-convex; probably made from thick flake. The straight basal margin is a natural surface pitted by sand-blast. The *arrêtes* of the flake-scars are slightly smoothed. Brit. Mus. (Nat. Hist.) Geol. Dept. *E.* 1454

(2) Miniature foliate 'hand-axe' in silica-glass. The narrow area on one face which shows shallow pitting is a remnant of a surface which was sand-blasted before the material was worked. The flaked surfaces are slightly smoothed by sand-blast. *E.* 1453

(3) Thin, twisted, bifaced foliate point in silica-glass. Slightly smoothed by sand-blast. Perforated by meandering tubular cavity, 0·6–1·5 mm. in diameter, which is blocked at the narrower end by a particle of loam. *E.* 1455

(4) Bifaced foliate point in silica-glass; plano-convex; probably made from a flake. All the edges are smoothed by sand-blast, the convex surface considerably so. *E.* 1456

(5) Bifaced foliate point in quartzite. Tip broken. Slightly worn by sand-blast. *E.* 1452

(ref. 1, see map, p. 434). It was found to lie most thickly around the expedition's Camp 7 (lat. 25° 17′ 54″ N., long. 25° 34′ 0″ E.). At several places there were groups of flakings, evidently where large lumps had been broken up by man. Only two small fragments were found upon the dune ridges. They occurred in company with an implement of quartzite and had evidently been carried there. One piece of silica-glass was found 240 km. south by east of the main area of distribution, and another piece 225 km. to the east-south-east. These, too, had probably been transported by man.

While undoubtedly natural, the origin of the Libyan silica-glass is uncertain. In its constitution it resembles the tektites of supposed cosmic origin, but these are much smaller. Tektites are usually black, although one variety found in Bohemia and Moravia and known as moldavite is clear deep green. The Libyan silica-glass has also been compared with the glass formed by the fusion of sand in the heat generated by the fall of a great meteorite, for example, at Wabar in Arabia and at Henbury in Central Australia. Reporting the findings of his expedition, Dr. Spencer (ref. 2, p. 506) said that he had not been able to trace the Libyan glass to any source; no fragments of meteorites or indications of meteorite craters could be found in the area of its distribution. He said: "It seemed easier to assume that it had simply fallen from the sky".

It would be of considerable interest if the time of origin or arrival of the silica-glass in the Sand Sea could be determined geologically or archæologically. Its restriction to the surface or top layer of a superficial deposit suggests that it is not of great antiquity from the geological point of view. On the other hand, it has clearly been there since prehistoric times. Some of the flakes were submitted to Egyptologists in Cairo, who regarded them as "late Neolithic or pre-dynastic" (ref. 3, p. 504). In spite of a careful search by Dr. Spencer and the late Mr. A. Lucas, no objects of silica-glass could be found in the collections from Tut-ankh-Amun's tomb or from any of the other dynastic tombs. No pot-sherds were encountered in the silica-glass area, but in the neighbourhood of the flakings some "crude spear-points of glass" were found, also some quartzite implements, "quern-stones" and ostrich-shell fragments (ref. 1, pp. 433, 435).

In the hope of throwing more light on the date of origin of silica-glass in the Sand Sea, all the artefacts of this material which Dr. Spencer deposited in the British Museum (Natural History) have been re-examined, together with those of other materials from the same area which he brought to England.

The artefacts collected were mainly from workshop sites in the region of Camp 7 in Street *B*, and in the neighbouring parts of Street *A* to the west (19 km. north of Camp 9) and of Street *C* to the east (west of Camp 10). The material preserved in the Departments of Mineralogy and Geology in the British Museum (Natural History) comprises: two bifaced foliate points, two small bifacial tools (miniature 'hand-axes'), one atypical core and more than 220 flakes and flake-blades of silica-glass; one bifaced foliate point and nine flakes and flake-blades of quartzite (silicified Nubian sandstone); two pieces of hæmatite. (These pieces of hæmatite were presumably brought into the area by man. The so-called quernstones, found, for example, in Street *C* in proximity to quartzite flakes, were probably for grinding hæmatite into red ochre (ref. 4, p. 71). A typical pair comprised a large flat lower stone of partly silicified Nubian sandstone, and a smaller bun-shaped upper stone (an oval boulder of the same sandstone, but of much coarser grain).)

All the flaked artefacts are of palæolithic facies. The flakes of silica-glass include a few large Clactonoid forms (that is, struck by the elementary *bloc-en-bloc* technique), while several are Levalloisoid (that is, struck from prepared cores). Many of the quartzite flakes and flake-blades are Levalloisoid. Indeed, since they show faceted striking-platforms in addition to evidence of preparation of the face of the core, they may be described with little hesitation as Levalloisian. In comparing the typology of the artefacts of the two materials, it has to be remembered that whereas any flake of silica-glass would have been kept by the investigators, the rougher flakes of quartzite would probably have been neglected. Moreover, the flaking qualities of quartzite and silica-glass are very different. A high percentage of the flakes of silica-glass are of

the narrow form now called 'flake-blades' (ref. 5, p. 91), and include curving spalls up to 9 cm. long (ref. 3, p. 504). It is noteworthy that the collection includes no true blades (that is, made by the punch technique); nor does it include any microliths.

The *bloc-en-bloc* and prepared-core techniques were used in Africa by various cultural groups extending over a long range of time, so that the Clactonoid and Levalloisoid flakes are not closely diagnostic of the age or cultural status of the silica-glass workshops. However, there are five artefacts in the collection noted above, all from Camp 7, and four of them in silica-glass, which indicate the Late Palæolithic culture known as Aterian—that is, the bifaced foliate points and the miniature 'hand-axes' (see illustration). The bifoliate points are the "crude spear-points of glass" noted by Dr. Spencer (ref. 1, p. 433). These figured specimens are now in the Department of Geology of the British Museum (Natural History).

These artefacts can be closely matched in the Aterian industries which occur in Morocco, Algeria and sparingly farther east, for example, in the Kharga Oasis (ref. 6). The Aterian is based on a Levalloiso-Mousterian ('Middle' Palæolithic) tradition, and is akin to the Still-Bay industries of the southern half of Africa. It is distinguished by the absence of the true blade elements which characterize the succeeding Capsian group of industries. Commonly 7 per cent or more of the artefacts in an Aterian industry are flake-blades (ref. 5, p. 121). The association of bifaced foliate points with certain types of 'hand-axes', including miniature forms, is one of the features of the Aterian industries noted by Miss Caton-Thompson (ref. 5, pp. 91, 97). The type-artefact of Aterian culture is the tanged-point, or arrow-head. It is regrettable that none is represented in the collection of silica-glass artefacts which has been examined (but it is perhaps worth recording that one of the pointed flake-blades from Camp 7 is accidentally pedunculate and most deceptively simulates the form of a blunted Aterian arrow-head).

While the only well-defined artefacts in silica-glass from the Sand Sea are almost certainly Aterian, one is not justified in concluding that all the flakings in this material are of the same age. Some may well be younger; for example, any which are contemporary with the ostrich-shell fragments and grinding stones are probably not older than Upper Sebilian (Mesolithic). But more important from the point of view of the present inquiry is the question of whether any are *older* than Aterian.

Some of the larger flakes of silica-glass might well be Early Palæolithic (Acheulean) waste-flakes; but they could equally well be the primary or 'quartering' flakes of an Aterian industry. Similarly, although their proximity to bifaced foliate points strongly suggests that they are Aterian, the miniature 'hand-axes' described above might be exceptionally small Acheulean hand-axes. However, it is true to say that no undoubtedly pre-Aterian artefact in silica-glass has been found.

At a point 24 km. south of Camp 8 in Street *D*, sixty large quartzite hand-axes of Upper Acheulean type were discovered lying on the surface with glossy sand-worn faces uppermost (ref. 1, p. 435). A few were deposited in the Cairo Museum; others were left *in situ* for further investigation. I have examined one specimen, regarded as typical of the group. It is a symmetrical biface with Gothic-arch tip, true-edged, 21 cm. long, 10·5 cm. wide, and with maximum thickness of slightly less than 5 cm. Associated with these large hand-axes there were quartzite waste-flakes. At the same site there were scattered pieces of silica-glass, but none appeared to have been worked. If Acheulean hunters had encountered silica-glass in pieces as large as those occurring, for example, in Street *C* about 10 km. to the west-north-west, it seems probable that they would have attempted to use it as raw material for hand-axes, just as they used the volcanic glass (obsidian) at Kariandusi in the Kenya Rift Valley (ref. 7, p. 36). The fact that no undoubted Acheulean artefacts in silica-glass have been found cannot be regarded as proving that this material was absent from the region during the period of that culture; for it is possible that such artefacts occur, but have not yet been found or recognized. Another possibility is that attempts by the Acheuleans to work the material into large hand-axes were unsuccessful owing to its brittleness and the consequent wastage. It must be remembered that large pieces of silica-glass may have been rare even at the time of its origin, whereas the supplies of obsidian at Kariandusi were probably large enough to allow considerable wastage in the manufacture of hand-axes.

Thus the archæological evidence allows us to go no further at present than to conclude that silica-glass was present in the Libyan Sand Sea in Late Palæolithic (Aterian) times. But it is important to bear in mind that the glass was already corroded by sand-blast before it was worked into the bifaced points. It should be noted here that the Acheulean and Aterian cultures may have been separated by a considerable interval, corresponding to the time when the basic Levalloiso-Mousterian culture flourished. The Aterian was technologically a derivative of the Levalloiso-Mousterian, and is now considered to have been broadly contemporary with the 'Aurignacian' and Solutrean cultures of Europe—that is to say, it has a probable antiquity of between 10,000 and 20,000 years.

Several artefacts of natural green glass (moldavite) were found in the 'Upper Aurignacian' (Gravettian) levels in the loess at Willendorf in Lower Austria (ref. 8), and one example, apparently from a Mousterian horizon, in the Gudenus Cave in the same region (ref. 9). It is also interesting to note that tektites have been found in the Trinil beds of Java, which are considered to be of about the same age as deposits containing remains of Acheulean culture in the west, that is, Middle Pleistocene (ref. 10). Thus the suggestion that Libyan silica-glass, moldavite, and other tektites represent 'glass-meteorites' which reached the earth within a limited period of time (ref. 11) at least appears consistent with the rather meagre archæological and geological evidence.

In conclusion, I should like to express my thanks to Dr. L. J. Spencer for the help he has given me in the preparation of this article.

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MISCIBILITY OF LIQUIDS INFLUENCED BY RATE OF SHEAR

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WHETHER or not phase separation will occur in a liquid system is a question of the mutual solubilities of its components. It is usually assumed that, if pressure and relative composition are held constant, the temperature alone determines these solubilities and thereby decides the question of demixtion, that is, the general phase state of the system. From experiments which we have performed it appears, however, that the assumption of complete determination of solubility by temperature at constant pressure and relative composition requires considerable amendment. Our results show that in the case of certain demixed liquid–liquid systems the maintenance of a field of flow (stirring) can affect the solubility and thereby the miscibility of the phases as profoundly as a change of temperature of, say, 10° C., or a 1·15-fold dilution. It was found that even relatively mild flow conditions suffice to bring about complete reversal of phase separation in these systems.

The systems referred to are formed when two macromolecular solutes, for example, polystyrene and ethyl cellulose, are dissolved in the same solvent, for example, benzene. In such cases phase separation sets in at very low solute concentrations and the two phases formed contain disproportionate amounts of the two solutes. A comprehensive study of such systems has been made in particular by Dobry and Boyer-Kawenoki[1]. Taking as example the system polystyrene – ethyl cellulose – benzene used in our experiments, it is found that a solution containing only 2–3 per cent total polymer (degree of polymerization about 1,000) is separated into two phases at room temperature. These phases again each contain 97–98 per cent benzene, but one is largely a solution of polystyrene with only a little ethyl cellulose, and the other is an ethyl cellulose solution with relatively little polystyrene.

The two phases obtained in this manner are similar in their behaviour to the phases obtained when two partially miscible liquids, for example, water and amyl alcohol, are mixed together.

The systems are dependent on temperature and, in the particular case of the system polystyrene – ethyl cellulose – benzene considered here, the mutual solubility of the phases is increased as the temperature is raised. More ethyl cellulose is dissolved by the phase rich in polystyrene and more polystyrene by the phase rich in ethyl cellulose. The compositions of the two phases of the unstirred system therefore approach each other as the temperature is increased, and for each given overall composition there exists a well-defined 'critical' solution temperature T_c at which phase separation just ceases and above which the system is homogeneous.

Overall concentration (% w/w)			T_c (°C.)	Relative volume of phases at 21·7° C. i.e., T_c–10° C. (vol. %)	
Benzene	Polystyrene	Ethyl cellulose		I	II
97·1	1·14	1·80	31·7	47	53

At 22° C. the above system is obviously 10° C. below its critical temperature and is separated into two phases. If, however, a velocity gradient of $q = 200$ sec.$^{-1}$ is maintained in this system (at 22° C.) a homogeneous one-phase solution results. There exists, in fact, a quantitative relationship between the number of degrees, ΔT (°C.), by which the system is below its critical solution temperature, and the rate of shear q (sec.$^{-1}$) which can completely reverse the phase separation at the temperature $T_c - \Delta T$. In the case of the particular system investigated by us, this is:

$$q = 20\ \Delta T. \qquad (1)$$

In order to illustrate the rates of shear necessary according to (1) to produce a noticeable shift in the critical solution temperature, consider a Couette apparatus, that is, a cylindrical drum (say, 5 cm. in diameter), rotating in a concentric cup (say 7 cm. in internal diameter), the interspace being filled with solution, and assume that the angular speed of rotation of the drum is 1 revolution per second. (These particular dimensions apply to the apparatus used by us. It is worth noting, by the way, that, as the viscosity of the solution is 0·11 poise, laminar flow conditions prevail up to about $q = 270$ sec.$^{-1}$.) Such a speed, which could easily be maintained by hand, would in this case correspond to a rate of shear $q = 27$ sec.$^{-1}$ and would, according to (1), suffice to change the critical solution temperature by 1·3° C.

The changes observed in this manner are completely reversible, that is, the system separates again (becomes turbid) as soon as the rate of shear drops below the values given by (1). The effect of the field of flow is thus to make the homogeneous system stable at temperatures at which the homogeneous system of the same composition, but at rest, is metastable. This means that the free energy of the stirred homogeneous system, and with it also the free energy of certain of its components, must be larger than the corresponding quantities of the resting, separated system at the same temperature.

The reversal of phase separation in a field of flow is intimately connected with the large interfacial area which is created when the separated system is gently stirred. An immediate break-up into fine drops takes place, their final size being determined by the hydrodynamics of flow. By simple dimensional analysis the mean linear dimension r of the largest drop which can exist in a laminar field of flow of velocity gradient q can be related to the interfacial tension σ and the viscosity η of the surrounding medium. We find:

$$r = \text{const.}\ \frac{\sigma}{\eta q}, \qquad (2)$$

where the constant of proportionality is dimensionless and of the order of 0·15 in cases where the difference between the viscosity of the drop and the viscosity η of the surrounding medium is small[2].

If it is assumed that the interfacial tension is left unaffected by the decrease in drop radius, equation (2) represents the effect of the field of flow on drop size for all values of q. Our experiments have shown that this is true only initially, that is, at low rates of shear, and only up to drop sizes of about 10^{-3} cm. Further decrease in drop size is found to result in a rapid decrease of interfacial tension and a complete reversal of the phase separation.

Experimentally, we infer the disappearance of the second phase from the disappearance of turbidity, that is, of optical inhomogeneity in the system. If this optical homogeneity had been produced according to (2), that is, by a mere reduction in size of drop, the necessary rate of shear would, obviously, have had to be 1,000 times greater than that required for

$r = 10^{-3}$ cm. Experimentally, however, we find a factor of only about 10, clearly showing, as stated, that a breakdown of σ must have occurred at some intermediate size of drop.

Theoretically, we can explain this phenomenon as follows. The interface between two phases is not infinitely thin, but represents a transition zone of inhomogeneous composition, of finite thickness and volume. If this thickness is ε cm. and if there are f sq. cm. of interfacial area per 1 c.c. of the system, then the interface occupies a fraction $f\varepsilon$ of the total volume. The interfacial tension may be defined as the free energy necessary to form ε c.c. of 'interface' out of the non-interfacial region of the system. The existence of f sq. cm. of interface therefore implies a free energy increase of $f\sigma$ ergs/c.c. relative to the state of the system in which $f = 0$. An isothermal approach in composition of the two phases would reduce σ, and therefore $f\sigma$, but would at the same time increase the free energy in the $(1 - f\varepsilon)$ c.c. not occupied by the interface. So long as f is small ($f\varepsilon \ll 1$), the change in composition, which must accompany a reduction in $f\sigma$, will therefore severely restrict this effect. In our case, ε is determined by the dimensions of the coiled polymer in solution and is, thus, of the order 10^{-5} cm. When the size of drop r is therefore smaller than about 10^{-3} cm., the interfacial volume, $f\varepsilon$, becomes comparable with 1, and an approach in composition leading to a reduction in total free energy, as well as in $f\sigma$, becomes possible. At constant rate of shear, q, this decrease in σ brings with it, as secondary effect, a further reduction in size of drop (see (2)), and, due to the increased value of f, a renewed change in composition. Equilibrium is reached between these tendencies at lower rates of shear, but there exists a critical value of q at which these effects so reinforce each other that there is a complete resolution of all differences in composition and a complete reversal of the phase separation.

In the above, we have given a somewhat simplified description. Thus, at constant q and σ, there can be a reduction in f, and therefore of $f\sigma$, by a solution of some of the dispersed phase in the surrounding medium (analogous to the increase of vapour pressure of small droplets by capillarity). This reduction in f is, however, in our case, where dispersed phase and surrounding medium are of roughly equal volume, accompanied by a correspondingly large change in composition. The two effects, the one mentioned now and that discussed in the preceding paragraph, are therefore on closer inspection seen to be non-separable phenomena.

It is clear that, as the size of drop, r, becomes comparable with ε, the definition of r, and with it the concept of capillarity, rapidly lose precision. The homogenization process at this stage may be pictured as a gradual replacement of the non-interfacial $(1-f\varepsilon)$-regions by the interfacial $(f\varepsilon)$-regions of the system (the interface will, in general, 'consume' one phase faster than the other). As $f\varepsilon \to 1$, the concentration gradient in the interface, for energetic reasons, tends to decrease, leading eventually to the homogeneous solution as the most stable state. The use of f and σ has here only a symbolic significance.

We have emphasized the fact that the homogeneous system has a larger free energy than the separated, unstirred system at the same temperature (as revealed by spontaneous demixing as soon as stirring is stopped). The otherwise unstable homogeneous state is thus maintained at the expense of a continuous degradation of mechanical into thermal energy in the field of flow. The rate at which thermal energy is produced under the conditions described by equation (1) in a medium of viscosity $\eta = 0{\cdot}11$ poise is obviously $\eta q^2 = 44(\Delta T)^2$ erg/c.c. sec. On the other hand, the time during which a noticeable demixtion would take place in the solution is roughly equivalent to the time, t, taken by the coiled polymer to diffuse a distance of the order of its end-to-end distance ($\sim 5 \times 10^{-6}$ cm.). Remembering that the diffusion constant of the polymer in a medium of this viscosity is about 10^{-8} cm.^{2}/sec., $t = \frac{1}{2}(5\times10^{-6})^2/10^{-8} = 1{\cdot}25\times10^{-3}$ sec. and the thermal energy produced in this time equals $5 \times 10^{-2}(\Delta T)^2$ erg/c.c. This we compare with the free energy required to homogenize 1 c.c. of the demixed system when it is ΔT° below T_c. Using the theory of Scott[1], it is easily shown that this energy is of the same magnitude, being in the present case about $6{\cdot}2 \times 10^{-2}(\Delta T)^2$ erg/c.c. The rate at which thermal energy is produced from mechanical energy in the field of flow is thus, indeed, sufficient to prevent the homogeneous system from demixing.

From the above it becomes clear that the effects observed (shift in solubility and critical solution temperature) need not be specific to systems with macromolecular components, although it can be seen why they are particularly large in such cases. Fundamentally the same situation arises in all liquid–liquid equilibria as well as in the case of liquid–vapour transitions and the corresponding critical phenomena. [Dec. 6.

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INFLUENCE OF SUBSTITUENTS ON THE MESOMORPHISM OF *p-n*-ALKOXYBENZOIC AND 6-*n*-ALKOXY-2-NAPHTHOIC ACIDS

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SINCE Reinhitzer's discovery of mesomorphism in 1888, a large number of organic compounds which show this phenomenon have been prepared. Their physical appearance and the texture of their mesophases have been extensively studied by Friedel and others; but there is at present little or no information concerning the molecular dimensions which determine whether a system will show mesomorphism, or of the effect of substituents on the range and character of the mesophases. Vorländer[1] discussed the significance of certain structural features, and Bernal and Crowfoot[2] attempted to indicate the types of structure which would lead to the formation of nematic and smectic phases. Weygand *et al.*[3] made a systematic study of certain homologous series of alkoxyanils, azo- and azoxy-compounds. Nevertheless, all that can be said is that to show mesomorphism an organic molecule must either be predominantly one-dimensional or rod-shaped, as in *p*-azoxyanisole, or saucer-shaped, as in the cholesteryl esters, thus allowing the close packing in both the crystalline and mesomorphic states. In no series, hitherto, has the influence of substituents been systematically studied.

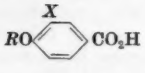
Table 1

	First appearance of: (a) nematic phase	(b) smectic phase	Smectic phase only	Maximum phase-length
X = H	$R = C_8H_7$	C_7H_{15}	$R = C_{12}H_{27}$	57° ($R = C_{16}H_{33}$)
F	C_9H_{17}	C_8H_{19}	$C_{16}H_{33}$	16° ($R = C_{16}H_{33}$)
Cl	C_8H_{17}	C_9H_{17}		4·5° ($R = C_{16}H_{33}$)

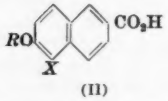
Table 2

	First appearance of: (a) nematic phase	(b) smectic phase	Smectic phase only	Maximum phase $R < C_{12}H_{25}$
X = Cl	$R = C_8H_7$	$R = C_8H_{13}$	$R = C_{14}H_{29}$ and $C_{16}H_{37}$	42° ($R = C_8H_{13}$)
Br	C_8H_7	C_7H_{15}	$C_{12}H_{25}$ and $C_{16}H_{37}$	40° ($R = C_7H_{15}$)
I	C_7H_5	C_8H_{17}	$C_{12}H_{25}$ and $C_{16}H_{37}$	25° ($R = C_8H_{17}$)
NO_2	C_9H_{19}	$C_{12}H_{25}$		1·5° ($R = C_{12}H_{25}$)

In an attempt to enlarge existing knowledge regarding the molecular dimensions which would appear to be necessary for mesomorphism to occur, an examination was recently made of the relative importance of length to breadth, or flat-area, in such molecules as the 4 : 1-, 5 : 1-, 6 : 2- and 7 : 2-*n*-alkoxynaphthoic acids[4]. Here, only the 6-*n*-alkoxy-2-naphthoic acids are mesomorphic. This investigation has now been followed by a study of the influence of substituents, particularly of the halogens, in the 3-position of *p*-*n*-alkoxybenzoic acids and in the 5-position of 6-*n*-alkoxy-2-naphthoic acids.



(I)



(II)

In the benzoic acids the effect of substituents is very marked. Introduction of the large bromine atom eliminates the mesomorphism completely. With chlorine and fluorine the mesophases persist, but their length is reduced, and their appearance in the series delayed. Thus, even with a fluorine atom, the nematic phase, which first appears in the unsubstituted acids in *p*-*n*-propoxybenzoic acid, is not found until the hydrocarbon chain is lengthened to octyl, in 3-fluoro-4-*n*-octyloxybenzoic acid. Moreover, in the unsubstituted acids a maximum phase-length of 57° is found in *p*-*n*-decyloxybenzoic acid[5,6]. In the fluoro-substituted acid the maximum phase-length is reduced to 16°, and in the chloro-acids it is only 4·5°. Both maxima are found in the *n*-cetyloxybenzoic acids. Some of the data are summarized in Table 1; the alkyl groups used were CH_3 to $C_{10}H_{21}$, $C_{12}H_{25}$, $C_{16}H_{33}$ and $C_{18}H_{37}$.

In view of these results, the absence of mesomorphism in 3 : 5-dichloro-4-*n*-alkoxy- and in 3-nitro-4-*n*-alkoxy- benzoic acids is not surprising.

A substituent in the alkoxynaphthoic acid (type II) affects its breadth (looked at along the line of axis of the O*R* and COOH groups) less than it does in the benzoic acid; even with a chlorine atom in the 5-position, the molecule is only a little broader than the parent acid. As a result, the decrease in the mesomorphism is far less marked than in the benzoic acids and, in all but the first members, mesomorphism persists throughout the chloro-, bromo- and iodo-alkoxynaphthoic acids. The influence of a nitro-group is much more striking, since its size and its polar character will probably affect orientation in the melt. The first eight acids in this series show no mesomorphism, but a short nematic phase appears in 5-nitro-6-*n*-nonyloxy-2-naphthoic acid. By contrast, a nematic phase is found in the unsubstituted 6-alkoxy-2-naphthoic acids in the 6-methoxy-acid, and the maximum phase-length in the first twelve members is 49° in 6-*n*-hexyloxy-2-naphthoic acid. The influence of increasing group size on the mesomorphism is shown in Table 2.

A particularly interesting feature of these results is the appearance of the smectic phase. In the chloro-acids, it emerges when *R* is hexyl, with bromine as substituent when *R* is heptyl, and with iodine when *R* is octyl. Thus, as the size of the halogen atom increases, this phase appears progressively later in the series.

It might have been expected that the appearance of the nematic phase would be affected similarly. That is, since a nematic phase is found with iodine and bromine as substituents in the butoxy- and propoxy- acids respectively, it might be found in the chloro-series in the ethoxy-acid. Actually, the lengths of the phases in 5-bromo-6-*n*-propoxy-2-naphthoic acid and in 5-iodo-6-*n*-butoxy-2-naphthoic acid are so short that they cannot be measured by normal methods (they persist for less than 0·1°). Moreover, the melting points of the ethoxynaphthoic acids are much higher than those of the propoxy-acids, and it is therefore not surprising that so short a phase is not found in 5-chloro-6-ethoxy-2-naphthoic acid with its high melting point of 264°.

When the alkyl group contains twelve or more carbon atoms, the effect of an increase in the size of the substituent, particularly of the halogen, is not so marked, and the halogeno-stearyloxynaphthoic acids become identical in their mesomorphic behaviour.

Table 3

	Phase-length			
	X = Cl	Br	I	NO_2
$R = C_{12}H_{25}$	35°	31°	24°	4°
$C_{16}H_{33}$	35°	34°	31°	4·5°
$C_{18}H_{37}$	35°	35°	35°	8°

These compounds are the first extended series of substituted mesomorphic substances to be examined in detail. The gradual decrease in mesomorphism in the naphthoic acids as the size of the substituent is increased, together with its elimination in the benzoic acids, are noteworthy.

A fuller account of this work will be published later. [Feb. 21.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

E Region during the Solar Eclipse of February 25, 1952

DURING an eclipse of the sun, changes in the electron density (N) in an ionospheric layer of Chapman type may be represented by the relation:

$$\frac{dN}{dt} = q - \alpha' N^2, \qquad (1)$$

in which q is rate of production of electrons and α' is effective recombination coefficient. If the ionizing radiation were emitted uniformly from all parts of the disk, q would be proportional to the fraction (A_x) of the disk unobscured by the moon. Observations made at optical frequencies show that the disk radiation is not uniformly distributed. Consequently, if we assume that the ionizing radiation has a similar distribution, it is necessary to represent q during an eclipse by two terms denoting the intensity of the radiation coming from the uniform ($A_x I_0$) and non-uniform (I_s) components respectively. Thus:

$$q = K \cos\chi\,(A_x I_0 + I_s), \qquad (2)$$

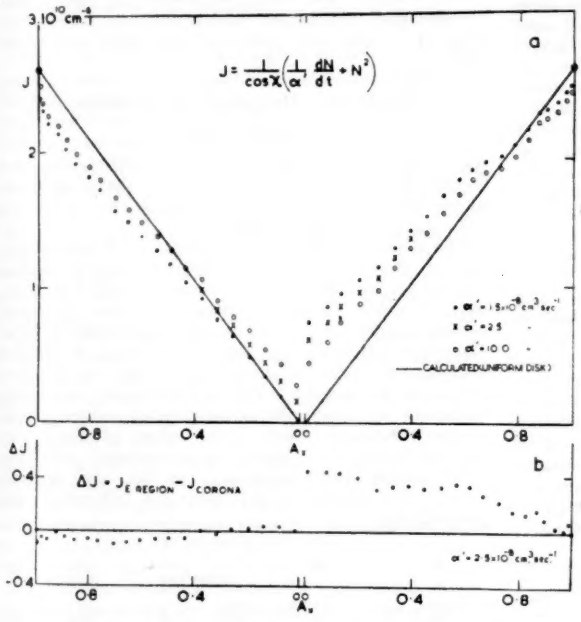
where K is a constant and χ is zenith angle of sun.

Substituting this in equation (1), we can write:

$$\frac{K}{\alpha'}[A_x I_0 + I_s] = \frac{1}{\cos\chi}\left[\frac{1}{\alpha'}\frac{dN}{dt} + N^2\right] (= J). \qquad (3)$$

On the right, $\cos\chi$ is known, and N and dN/dt can be deduced from the changes in E-region critical frequency (*foE*) during the eclipse. Hence the values of J calculated from ionospheric measurements can be compared with those obtained by inserting different values of I_0 and I_s in the left of equation (3).

Measurements of *foE* were made at intervals of four minutes at Khartoum during the total solar eclipse of February 25, 1952. The standard deviation of the error in measuring *foE* was about 0·01 Mc./s. and, since special precautions were taken to ensure accurate timing, the maximum error in calculating dN/dt is probably about ± 10 per cent. J has been computed for several values of α', and the experimental points are shown in Fig. 1 with the computed values for a uniformly radiating disk. J has been plotted as a function of A_x since the slope of the line through the points is then proportional to I_0 (equation 3).



(1) Change in $J = q/\alpha'$ cos χ during total eclipse, calculated from E-region measurements. (2) Difference between J derived from E-region measurements and from intensity distribution of coronal line 5303 A.

The observations imply that the uniform (J_0) and non-uniform (J_s) components have magnitudes: $J_0 = 200 \times 10^8$ cm.$^{-6}$; $J_s = 60 \times 10^8$ cm.$^{-6}$. Part of the non-uniform component is divided about equally between the east and west limbs of the sun, since a sharp fall in J occurred just after first contact and a similar rise preceded fourth contact. It also seems probable that J did not fall to zero during totality.

These conclusions are consistent with the distribution of intensity over the disk of the green coronal line, information on which has been obtained through the courtesy of M. L. d'Azambuja, of the Paris Observatory at Meudon. The difference between the value of J calculated from the coronal data, assuming an extension to 1·04 solar diameters, and from the E-region measurements, assuming $\alpha' = 2{\cdot}5 \times 10^{-8}$ cm.^{3} sec.$^{-1}$, is shown in Fig. 2. The main discrepancy appears abruptly just after totality, and suggests the existence of an intense source of ionizing radiation near the west limb of the sun which cannot be accounted for in terms of the solar data available at present. If J is not allowed to become negative just before totality, the minimum possible value of α' is $1{\cdot}5 \times 10^{-8}$ cm.^{3} sec.$^{-1}$. This would imply that J rose from 0 just before, to 73 ± 10^8 cm.$^{-6}$ just after, totality, and also that 28 per cent of all the ionizing radiation was emitted from 0·4 per cent of the disk area. On these grounds a somewhat higher value of α' may be required, at least near totality.

A fuller account of these and other ionospheric measurements made during the eclipse will appear elsewhere. The work described above was carried out as part of the programme of the Radio Research Board and this note is published by permission of the Department of Scientific and Industrial Research.

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Observation of a τ-Meson

Another example[1-3] of a τ-meson has been found, on an Ilford *G5* plate, 1,200 microns thick, exposed on Mount Rosa (4,550 m. above sea-level) surrounded by an aluminium absorber 5 cm. thick.

The τ-particle enters the emulsion from the glass almost horizontally, and, after travelling for about 8,000 microns, decays at rest into three particles, with tracks *a*, *b* and *c* (see photograph). The first two of these go into the glass after 2,600 and 2,000 microns in the emulsion respectively; the third, *c*, is much shorter and goes into the air after 100 microns.

The three tracks, *a*, *b*, *c*, are sufficiently long to allow accurate measurements of the projected angles between them and of their dips. We find the following: dip of $a = -29°$; dip of $b = -36°$; dip of $c = +49°$; angle $ab = 115° 30'$; angle $ac = 114° 30'$. With these values one can verify that the three tracks are coplanar within $\pm 1°$ and lie in a plane inclined about 51° to the plane of the emulsion. The true angles are: angle $ab = 91°$; angle $ac = 127°$.

Accurate measurements by grain counting have been carried out on the first two tracks, *a* and *b*, and less accurate ones on the third, *c*. The values obtained are: $68{\cdot}5 \pm 1{\cdot}9$, $49 \pm 1{\cdot}8$, and $37 \pm 4{\cdot}3$ grains per 100 microns respectively. These values have been referred to the ionization versus range relation experimentally determined for μ-mesons of the same part of the plate. In this way, we have found that the number of grains of the three tracks, *a*, *b*, *c*, are the same as those of μ-mesons at distances of 4·8 mm., 10·3 mm. and 17·5 mm. from the end of their range. If we suppose that the three tracks are due to π-mesons, we obtain in this way for their energies the following values: for *a*, $17{\cdot}4 \pm 0{\cdot}7$ MeV.; for *b*, $27{\cdot}3 \pm 1{\cdot}2$ MeV.; and for *c*, 37 ± 5 MeV. The independent measurements of the mean angle of scattering for the first two tracks *a* and *b*, which give $\bar{\alpha}_a = 0{\cdot}98° \pm 0{\cdot}16°$ and $\bar{\alpha}_b = 0{\cdot}47° \pm 0{\cdot}18°$, are fairly consistent with the previous assumption.

Assuming that the total momentum of the three particles is zero, and that all three of them are π-mesons, one can easily calculate with the preceding data the mass of the τ-meson. Giving most weight to the grain-counting measurements, and assuming alternatively as exact the determinations relating to track *a* or to track *b*, we obtain the following results:

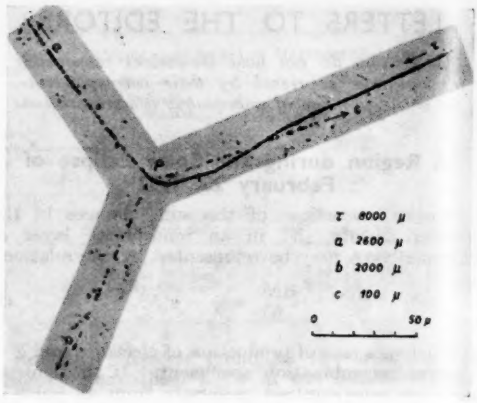
Kinetic Energy in MeV.

	Track *a*	Track *b*	Track *c*	Total	Mass of the τ-particle
Based on *a*	17·4 ± 0·7	28·2	43·3	87·9 ± 6·8	994·1 m_e
Based on *b*	16·8	27·3 ± 1·2	41	85·1 ± 7·2	988·6 m_e
Mean	17·1	27·8	41·6	86·5 ± 5	991 ± 15 m_e

In estimating the probable error, we have taken into account not only the errors in the grain counting and the measurement of the angles but also the lack of precision on the value of the thickness of the emulsion and the errors in the mass of the π-meson ($274 \pm 2\ m_e$).

The great length of the track of the τ-meson itself in the emulsion allows us to make two direct and independent measurements of its mass, based on the angle of scattering and range and on the ionization and range relations.

For the first, we have divided the track in parts of 1 mm. and have measured the angle of scattering for each of them, and hence the energy (for a low-energy



track one can obtain directly the energy from the $p\beta$ value without knowing the mass). The energy versus range relation is found to be:

Range	500	1,500	2,500	3,500	4,500	5,500	6,500 microns
Energy	7·8	13·1	16·3	21	24·2	27·6	32 MeV.

The corresponding mass of the particle is $946 \pm 140\ m_e$.

For the second, the gap/range relation for the τ-particle has been plotted and compared with gap/range relations for protons and μ-mesons; in this way a value for the mass of $995 \pm 150\ m_e$ has been found. As a mean value from the two direct measurements we can take $970 \pm 100\ m_e$, in fair agreement with the preceding determination.

The accuracy in the determination of the data of two of the disintegration tracks, *a* and *b*, enables us to test, by means of the conservation of momentum, whether the event considered can be interpreted satisfactorily only by assuming that the three disintegration tracks are due to π-mesons, or whether alternative modes of decay, including one or more μ-mesons, are possible. We have therefore calculated, assuming as exact the experimental values of the energy relating to track *a*, the values of the energy for the other two tracks in accordance with the conservation of momentum, in all the possible cases. We obtain in this way the following eight possibilities:

Kinetic Energy in MeV.

a	*b*		E_a	E_b theoretical	E_c theoretical	E_b experimental	E_c experimental
π	π	π	17·1	27·8	41·6	27·3	37
π	π	μ	17·1	27·8	49·7	27·3	28·9
π	μ	π	17·1	33·7	41·6	21·3	37
π	μ	μ	17·1	33·7	49·7	21·3	28·9
μ	π	π	13·6	17·8	27·0	27·3	37
μ	π	μ	13·6	17·8	33·5	27·3	28·9
μ	μ	π	13·6	22·5	27·0	21·3	37
μ	μ	μ	13·6	22·5	33·5	21·3	28·9

We see that the only cases in which there is complete agreement for the three tracks between theoretical and experimental values within the experimental errors are the first and the last; that is, either if the three tracks are all π-mesons, or if they are all μ-mesons. But in this last case the total energy of the three tracks would be 63·8 MeV., and that would give for the mass of the τ-meson the value 766 m_e, which is well outside the probable error of the direct determination of mass of $970 \pm 100\ m_e$. We think, therefore, that our analysis gives direct evidence that the three decay products of the τ-meson are all π-mesons, even without reference to preceding similar events, in which the nuclear interaction[1] or the direct measurement[3] of the mass of one of the

secondaries has already given evidence that at least one of them was a π-meson.

It is interesting to observe that our detailed analysis of the event was made possible by the fact that it took place in a very thick emulsion; for the great inclination of the plane of the π-mesons to the plane of the emulsion would not otherwise have allowed the tracks to be sufficiently long for that purpose.

We wish to acknowledge the help of the Brussels group and especially of Prof. G. Occhialini in developing the plate. The event was discovered by Mr. M. Greco.

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Detection of *S* Waves in the Earth's Inner Core

A theoretical calculation by one of us[1] shows that, if the earth's inner core has a rigidity comparable with its incompressibility, then the seismic phase *PKJKP* would, on present available knowledge, be most likely to be detected over a range of epicentral distance Δ given by $130° \leqslant \Delta \leqslant 155°$, the expected energy and amplitude in this phase being about 0·04 and 0·2, respectively, of that in the companion phase *PKIKP*. The phase *PKJKP* appears, therefore, to be on the border of observability and, if the solidity of the inner core is to be established, it becomes important to investigate the practical question of detecting a phase of such low amplitude.

The difficulty of the process of detection has been sharply focused by work of one of us (T. N. B.-G.), who has searched for the phase *PKJKP* over the series of seismograms recorded at the Riverview College Observatory from 1909 to the present day. The work, details of which are to be published elsewhere, shows that, of the whole series, there were only seventeen shocks for which Δ was in the above range and for which the amplitude of P' was greater than or equal to 4 μ. Of these seventeen shocks, Δ was approximately in the range 142°–145° in ten cases, and there was a fair probability that the observed P' related to a branch other than *PKIKP*. Of the remaining seven shocks, one had P' amplitudes of 6 μ, two of 5 μ and four of 4 μ. In the case of P' amplitude 6 μ (at $\Delta = 133°$), there were microseisms of amplitude 3 μ near the theoretical arrival-time of *PKJKP* and no impulse was observed. In one of the cases of P' amplitude 5 μ, microseisms were significant, and in the other the seismogram was changed at the expected *PKJKP* arrival-time. In the cases of P' amplitude 4 μ, there were movements near the expected arrival-time of *PKJKP* of amplitudes greater than or equal to those of P'; the size of these amplitudes means that they must be attributed to other causes.

The "International Seismological Summary" is of limited value in the search for *PKJKP* as it does not record amplitudes. A search was made over a section of the "Summary", and, while a limited number of recorded impulses were found to agree with the travel-time of *PKJKP*, it was not possible statistically to make any inference.

The main point which emerges from this investigation is the relatively small number of records from which the existence of the phase *PKJKP* is likely to be substantiated. It appears that, unless a record is traced far inland where microseisms are negligible, a prerequisite for observation of *PKJKP* is that the *PKIKP* amplitude should be at least about 20 μ. Not one of the Riverview seismograms over a period of more than forty years both conforms to this criterion and has the value of Δ in the correct range. The important question as to whether the earth's inner core is solid can therefore not be decided in this way, unless many routine observatory workers would be willing to record significant onsets (preferably on vertical component seismograms) within 20–30 sec. (say) on either side of the expected arrival-time[2] of *PKJKP*, whenever the *PKIKP* amplitude reaches 20 μ. The first of the signatories to this letter would appreciate it if details of such recordings could be transmitted to him. It appears that the best ranges to consider are $130° \leqslant \Delta < 142°$, $145° < \Delta \leqslant 155°$ (for $142° \leqslant \Delta \leqslant 145°$, it is difficult to estimate the amplitude of *PKIKP*).

It may be remarked that in the large earthquake of November 25, 1941 ($\varphi = 37·5°$ N., $\lambda = 18·5°$ W.), the P' amplitude at Riverview was 74 μ, while amplitudes of 11 μ and 15 μ were recorded on the vertical component, respectively 2 sec. before and 11 sec. after the expected arrival-time of *PKJKP*. The value of Δ for this earthquake is 171°, for which the calculated amplitude of *PKJKP* is only 0·03 times that of *PKIKP*. The theoretical amplitude calculations could be in appreciable error if the region *F* of the earth[3] differs seriously from the simple model assumed in the calculations, so that the onsets recorded at Riverview in the case of this earthquake could just possibly be significant in relation to *PKJKP*. It is suggested that the records of this earthquake might well be examined at observatories within the ranges of distance mentioned in the previous paragraph.

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[1] Bullen, K. E., *Mon. Not. Roy. Ast. Soc., Geophys. Supp.*, **6**, 163 (1951).
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Silver Films and Dielectric Multiple Films in Interferometry

The work on multi-layer dielectric films as described recently by A. H. Jarrett and H. v. Klüber[1] is of interest in two respects: the reflectivities reported are rather higher than those found by other workers, and the successful use with étalons shows that these films must have a considerable degree of uniformity. But the comparison of the relative merits of these films and silver films for use with Fabry–Perot interferometers is very misleading. Jarrett and v. Klüber do not mention recent publications on the resolving power of silvered étalons and the reflectivity of

evaporated silver layers[2]. If the measurements published in these papers are taken into account, it is apparent that multilayer coatings are not superior, in the range of wave-lengths over which they have been investigated, to evaporated silver films of good quality.

The value $R = 0{\cdot}90$ does not represent the "useful upper limit" of the reflectivity of silver layers (as is stated by Jarrett). The direct measurements made with new layers by Kuhn and Wilson show that, for a transmissivity of 0·02, the reflectivity varies from 0·97 to 0·96, and the absorption from 0·01 to 0·02 over the range of wave-lengths from 6800 to 5200 A. The performance of these silver layers is thus slightly superior to that of Jarrett's multilayer coating, which was found to have a reflectivity of 0·97 and an absorption of 0·02 in this region. The reflectivity and absorption of silver films three weeks old are about the same as for multilayer films. Towards shorter wave-lengths the efficiency of both silver and dielectric films decreases, but not enough quantitative data for the latter are available to allow comparison.

In practice, very high reflectivities are not used with étalons, since the limiting factor to the resolving power is the accuracy of working of the surfaces of the plates. With plates of good quality, the errors are not substantially smaller than 1/50 fringe; and since a reflectivity of 0·95 produces fringes with a width of 1/60 of an order, there is little to be gained by using layers denser than that required to produce this reflectivity. The width of the fringes of the line 5436 is estimated by v. Klüber to be 1/34 order, equivalent to a reflectivity of 0·91. The measured width of fringes produced with silver layers was 1/39 order, for films with a transmissivity of 0·04. These fringes were thus narrower than those produced by the multilayer coating, but in both instances the fringe-width was probably substantially increased by imperfection in the surfacing of the plates.

Judged on the basis of existing experimental data, multilayer films offer the advantage of a very slight gain in intensity in the range of lower reflectivities, below about 0·9. This should make them useful as étalon coatings for special purposes; if they could be made to operate for violet and ultra-violet light, they might gain considerable importance in spectroscopic interferometry.

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[1] *Nature*, **169**, 790 (1952).
[2] Bright, R. J., Jackson, D. A., and Kuhn, H., *Proc. Phys. Soc.*, A, **62**, 225 (1949). Kuhn, H., and Wilson, B. A., *Proc. Phys. Soc.*, B, **63**, 745 (1950), and references given there.

The silver films reported by D. A. Jackson and K. Kuhn are very efficient; considerably more so than those quoted by previous workers[1].

In this connexion, I wish to state that I have recently produced silver films possessing a reflectivity of 94 per cent and an absorption coefficient as low as 0·03 for $\lambda = 5461$ A., so giving an efficiency similar to that recorded by Kuhn and Wilson[2] for an aged silver film at 5200 A. Extreme care was exercised with regard to the cleanliness of all the surfaces in the vacuum vessel.

From a graph in the same paper, for an aged silver film at 5200 A., one concludes that $R = 0{\cdot}97$ for $T = 0{\cdot}005$, that is, $A = 0{\cdot}025$. These values may be compared with those for the multilayer coatings which were the subject of a previous communication[3]:

Coating	R (per cent)	A (per cent)	T (per cent)	$\tau = \left(\frac{T}{T+A}\right)^2$
Silver (fresh)	97	2·0	1·0	0·11
Silver (aged)	97	2·5	0·5	0·03
9-Layer dielectric	97	2·0	1·0	0·11
Silver (fresh)	94	2·0	4·0	0·44
Silver (aged)	94	3·0	3·0	0·25
7-Layer dielectric	94	1·0	5·0	0·69

(The figures for silver are from Kuhn and Wilson's results for 5200 A., ref. 2.)

The multilayer coatings were measured during the two days following their production.

Since the underlying motive for pursuing the multilayer investigations was to obtain as large a transparency (τ in the table) as possible for the étalon compatible with a small fringe half-width—a feature of supreme importance for phenomena, such as solar flares, etc., of limited duration—the conclusion from the above is that the multilayer coatings possess the greater transparency for the lower reflectivity cited; but for the higher value the freshly prepared silver films of Kuhn and Wilson appear their equal. It must be stressed, however, that the multilayer characteristics were not obtained immediately after deposition.

The comments in the foregoing correspondence appertaining to the possibilities of multilayer coatings for the blue end of the spectrum would depend on suitable dielectrics being obtained exhibiting little absorption in this region; zinc sulphide, for example, has an absorption band[4] at 3650 A.

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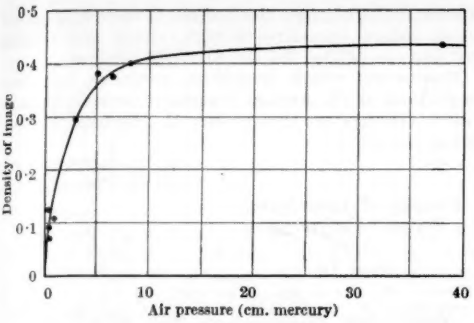
Russell Effect on Evaporated Metal Films

In 1897, Russell[1] discovered that freshly abraded metal surfaces produce an image on photographic plates and suggested that hydrogen peroxide is responsible for this action. Although a considerable amount of work was done on this subject in the first decade of this century, the only more recent publication is a paper by Churchill[2]. Work in the Mechanical Engineering Research Laboratories at Thorntonhall confirms that hydrogen peroxide is produced whenever fresh surfaces of certain metals are exposed to the action of water and oxygen. When, for example, aluminium, magnesium, nickel or zinc is cut under water, measurable quantities of hydrogen peroxide are produced[3].

Recently, we have found that evaporated films of metals, when exposed to the action of oxygen and water vapour, are capable of producing an image on photographic plates. Before briefly describing the



experimental procedure used, it is necessary to state that no satisfactory explanation of the cause of the Russell effect has so far been advanced. In our view, it is caused by the availability of free electrons on freshly exposed metal surfaces, as recently described by Kramer[4]. The following reactions then lead to the formation of hydrogen peroxide :

$$e + H^+ {}^-OH \rightarrow H^{\cdot} {}^-OH \rightarrow H^{\cdot} + (:OH)^- \quad (1)$$

$$H^{\cdot} + O_2 \rightarrow HO^{\cdot}_2 \quad (2)$$

$$HO^{\cdot}_2 + H_2O \rightarrow H_2O_2 + {}^{\cdot}OH. \quad (3)$$

The hydroxyl radicals disappear either through

$$e + {}^{\cdot}OH \rightarrow (:OH)^- \quad (4) \text{ or } 2.OH \xrightarrow{\text{third body}} H_2O_2. \quad (5)$$

The experimental investigation of the Russell effect with evaporated metal films was carried out in the following manner. Using a conventional evaporator, metal was evaporated *in vacuo* on to a glass slide fixed on a small carriage. After evaporation, and without breaking the vacuum, the carriage was allowed to slide into a light-tight box holding a thoroughly outgassed Ilford 'half-tone' plate. Air containing a certain quantity of water vapour was admitted to the evaporator. After 24 hr. the plate was removed and developed by a standard procedure. The optical density of the plate was measured by means of a photometer.

The experimental results show that, at a given ratio of water vapour to oxygen, the optical density increases at first with the increase in air pressure. At higher air pressures the density becomes independent of the pressure. This is illustrated in the accompanying graph, which shows the results obtained with an evaporated film of aluminium, using air containing 1·8 per cent by volume water vapour.

Complete results of the investigation will be published elsewhere.

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[4] Kramer, J., "Der Metallische Zustand" (Göttingen, 1950); *Z. Phys.*, 125, 739 (1949); **128**, 538 (1950); **129**, 34 (1951).

Adaptive Mechanisms of Buffaloes to Ambient Temperature

Animals of diverse origin vary widely in their capacity to withstand severe climatic conditions. Breed differences in the response to high external temperatures and humidity were demonstrated by Rhoad[1]. Buffaloes have a lower level of respiration-rate, body-temperature and pulse-rate than cattle[2]. Under shade, they have a better cooling mechanism than cows, as has been shown in India[3]. The black-pigmented skin assists the absorption of infra-red rays with a subsequent rise in body-temperature[4], while in thin-skinned animals heat penetrates easily, resulting in over-heating of the body and interference with efficient elimination of heat[5]. Shedding of hair in cattle is a seasonal phenomenon[6].

Six non-pregnant buffalo cows (eight years old) were kept in open stable during 7–10 a.m., exposed to direct sunlight for two hours starting at 10 a.m., and then removed to shade until 2 p.m. Respiration-rate, body-temperature and pulse-rate were recorded every ten minutes at intervals from 7 to 8 a.m. and from 10 a.m. to 2 p.m. The fluctuation in the three items were measured and expressed as deviations from the normal deviation[7]. Atmospheric temperature (which ranged from 23·5° to 43·0° C.) and relative humidity (which ranged from 40 to 79 per cent) were recorded throughout the experiment. Shedding of hair, colour of hide, and thickness of skin (measured at shoulder) were carried out on fifty buffaloes.

No noticeable variations were observed in respiration-rate, body-temperature and pulse-rate between 7 and 8 a.m. in the shade. Soon after exposure to sunlight, both respiration-rate and body-temperature began to rise. The increase in pulse-rate during the first hour of exposure fluctuated. During the second hour of exposure, the respiration-rate increased to a smaller extent than during the first hour. The increase in both body-temperature and pulse-rate was nearly double the increase occurring during the first hour. When the animals were removed to shade, there was a sudden decline in respiration-rate. This decline occurred after a latent period, of ten minutes for body-temperature and forty minutes for pulse-rate. The percentage of increase in respiration-rate, body-temperature and pulse-rate during the two hours of exposure to sun was followed by a similar decrease at the end of the first hour of shade. The relative decrease in body-temperature was greater than in respiration-rate and pulse-rate during the second hour of shade.

Newly born buffalo calves have long dense hair of brownish steel-grey colour. As the animals grow older, the density of the hair becomes less. Shedding usually takes place at the age of three years. Pregnancy and lactation hasten shedding of hair. Shedding of hair occurs at the end of spring and at the beginning of summer months. The pigmentation of the buffalo skin varies from black to steel-grey. When the animals are kept in close confinement, the skin loses its pigmentation and becomes reddish-white. The pigmentation is regained after removal to direct sunlight. The skin of the buffalo is flexible and its thickness varies with age (see accompanying table). The brisket skin in the buffaloes is well developed,

Thickness of buffalo skin (mm.)

Age	Calves	1–2 yr.	2–3 yr.	Mature
Skin thickness	4·47±0·4994	5·40±0·7849	5·48±0·1094	6·01 ± 1·447

and on exposure skin secretions are usually noticed between the fore-limbs as well as between the hind-limbs around the udder.

Respiration-rate in the buffalo increases on exposure to hot conditions whereas the rise in body-temperature is delayed. When removed from sunlight to shade, the respiration-rate was also first affected. It would seem that the respiratory tract is the first means of dissipating heat accumulated in the animals. As the respiratory movements cannot cope with the extra elimination of heat from the body, the pulse-rate is increased reflexly, but after a latent period. The increase in pulse-rate may be regarded as an attempt to stimulate the peripheral circulation and so helps heat loss through increasing salivation and skin secretions. Further investigation is needed to clear up the mechanism of peripheral circulation as affected by ambient heat. After one hour of shade, the buffaloes were able to lose almost all the heat gained at the time of exposure. The time required for eliminating extra heat through exposure needs investigation also.

The adaptive mechanism of the buffalo to hot humid climates is characteristic to the breed. The black-pigmented hide absorbs the infra-red rays of solar radiation and thus limits the animal's adaptability to exposure to sunlight. Such exposure does not occur under either wild or domesticated conditions. In the shade, however, the black coloration aids heat dissipation. The thick skin of the buffalo may prevent heating of the body from hot air and by radiation from the sun or hot ground. Hence we believe that although the buffalo is surviving in hot zones, where humidity is high, shade and cooling systems are needed for the animal's comfort.

This work, which is still in progress, has been carried out at the Animal Breeding Research Station, Cairo. Thanks are due to Mr. M. Ibrahim for statistical advice.

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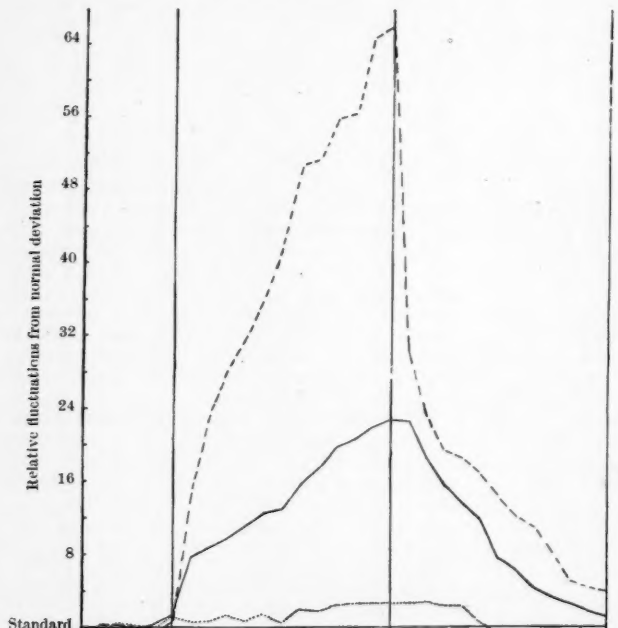
Photoperiodic Behaviour of *Hibiscus sabdariffa*, L.N.P.5

Hibiscus sabdariffa, L., is one of the most important fibre plants of India, commonly known as roselle fibre. There are several well-known varieties[1]. The plants can be grown on all types of soils, and hence the economic possibilities are considerable. A study of photoperiodic effects was undertaken in May 1951, since the strain was found to grow best when sown during May–June.

For a study of the photoperiodic effects of the plant, seeds obtained through the courtesy of the Indian Agricultural Research Institute, New Delhi, were sown in earthenware pots of 13-in. diameter in a circle equidistant from the rim and the centre of the pot on May 21. By May 25, the cotyledons were unfolded and the plants were ready for treatment. There were four plants per pot and three pots per treatment, so that twelve plants were taken for each treatment. Light periods ranged from eight hours to sixteen hours; for light periods longer than normal, additional illumination was provided from an electric bulb (100 candle-power) at a distance of 1 m., while for the shorter light periods the plants were taken inside a ventilated dark chamber for the required period before dusk and were brought back to the field after nightfall.

The results are given in the accompanying table as the mean of the readings for twelve plants per treatment. Flowering time denotes the time taken for the initiation of the first visible flower-bud, and fruiting time, the appearance of the first visible fruit. In addition, the total height of the plant and the circumference at the base of the stem on the flowering day were noted separately for each plant.



Relative fluctuations of body-temperature, respiration-rate and pulse-rate of buffaloes in sun and shade, under normal (7–8 a.m.) and experimental (10 a.m.–2 p.m.) periods

Treatment	Mean height at flowering in cm.	Mean basal circumference of stem at flowering in cm.	Mean flowering time in days	Mean fruiting time in days
8 hr.	93·8	2·984	87·5	92
10 hr.	71·36	2·125	69·25	75
12 hr.	210·7	4·1	126	131
14 hr.	240·783	4·6	141	150
16 hr.	235·066	5·28	154	162
Control	236·7	5·0	122	127

The daily light period of the normal plants rose gradually from 13 hr. 20 min. on May 25 to 13 hr. 31 min. on June 22 and again fell gradually to 12 hr. 5 min. at the time of flowering.

It is evident that *H. sabdariffa, L.N.P.5*, has a very definite photoperiodic response and is a short-day plant flowering fifty-three days earlier than the control under the short-light period of 10 hr. At 8 hr., however, there is an average delay of nineteen days from those at 10 hr. At longer photoperiods flowering is delayed. The earliness of flowering is very marked at 10 hr. while a conspicuous delay occurs among the 14- and 16-hr. groups. Bolhuis[2] noted and Ergle *et al.*[3] confirmed the fact that flowering in *H. sabdariffa* var. *altissima* is strongly influenced by the length of day. The behaviour of *H. sabdariffa, L.N.P.5*, appears to be similar.

My thanks are due to Dr. J. C. Sen Gupta for his interest in the work.

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[1] Howard and Howard, Memoir Dept. Agric. Ind., Bot. Series 4, 9 (1911).
[2] Bolhuis, G. G., *Landbouw*, **16**, 404 (1940).
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Effects of Preliminary Treatment on the Subsequent Variation in the Resistance of *Lemna minor* to the Phytotoxic Action of 2 : 4 Dichlorophenoxyacetic Acid

DURING a study of the inter-relationships between light intensity, temperature and the biological effects of 2 : 4 dichlorophenoxyacetic acid, it was found in the case of *Lemna minor* (duckweed) that when the concentration of the growth regulator in the external water culture solution was sufficiently high to kill some of the fronds at the end of three days exposure, then the mortality increased with decreasing light intensity over the range of continuous illumination 700–180 ft. candles. It was further observed that, whereas the degree of toxicity was markedly dependent on the light intensity received by the fronds prior to treatment with the dichlorophenoxyacetic acid ('pre-treatment period'), yet similar variations in the intensity during the following short 'treatment period' of three days had no effect.

Since the ratio of area to weight was increased at low levels of light, it was at first thought that this larger proportion of surface was associated with a greater uptake of the toxicant. However, as the product of the area–weight ratio and the concentration required to produce a 50 per cent mortality (the 'L.D. 50' determined by probit analysis) was not constant this explanation seems unlikely. Furthermore, when fronds in the pre-treatment period were treated with low and non-lethal concentrations of dichlorophenoxyacetic acid, although the area to weight ratio was little affected, the concentrations required to give a 50 per cent kill in the following treatment period were greatly increased. Thus, while without initial pre-treatment the required concentration of the acid was 81 p.p.m., it rose to 91, 116 and 193 p.p.m. after the fronds had been exposed respectively to 2·5, 10 and 40 p.p.m. in the previous twenty-four hours.

The next step was to determine whether this increased resistance induced by the pre-treatment was a specific effect. Accordingly, experiments were carried out in which fronds in the initial period were placed for twenty-four hours in low concentrations of a number of other compounds—for example, 2-methyl-4-chlorophenoxyacetic acid, 2 : 4 dinitro-*o*-cresol and cupric sulphate. In each case, such an initial treatment increased the resistance to dichlorophenoxyacetic acid in the treatment period. For example, pre-treatment with dinitro-*o*-cresol at 0·5 p.p.m. demanded a rise from 83 to 148 p.p.m. in the concentration of the phenoxyacetic acid needed to bring about the standard 50 per cent mortality.

When in the pre-treatment period the time of exposure to 40 p.p.m. dichlorophenoxyacetic acid was varied from 0·75 to 48 hours it was found that the induced increase in resistance to the *same* compound reached a maximum and steady value at the end of 3 hr., but that treatment for as little as 0·75 hr. had a significant effect. It is not possible to rule out enzyme adaptation as an explanation for the results of this experiment, since even within the short periods recorded many 'generations' of an enzyme may have taken place. However, on this basis, it is difficult to account for the common effect of different compounds on the subsequent response of *L. minor* to dichlorophenoxyacetic acid.

The results will be reported more fully and discussed in greater detail elsewhere. The techniques of the *Lemna* culture and the methods of probit analysis have been previously described[1–3].

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Neurospora following a Volcanic Eruption

EARLY in 1951, Mount Lamington in New Guinea erupted violently, and the resulting shower of hot ashes which followed the explosion devastated many miles of the countryside, causing severe damage and loss of life. Very soon after the eruption, Mr. G. A. Taylor, volcanologist stationed in New Guinea, visited the area, and in the course of his investigations found large patches of a pink fungus which he collected and sent for identification. The fungus was readily isolated and proved to be a heterothallic species of *Neurospora*, which has been provisionally identified as *N. crassa* (Shear and Dodge). The genus *Neurospora* is well known as a troublesome pest of bakeries and similar high-temperature situations. The ascospores of this genus do not germinate readily unless subjected for a brief period to high temperatures (for example, 1 hr. at 60° C.). Its occurrence,

therefore, in the Mount Lamington area, while not at all surprising to mycologists, is an interesting example of the invasion of an unusual ecological niche.

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July 7.

Occurrence of Putrescine in Potassium-deficient Barley

The identification of primary effects of potassium in plant cells has proved to be one of the most elusive problems in mineral nutrition. Many widespread physiological disturbances accompanying potassium deficiency are well known, especially in the fields of nitrogen and carbohydrate metabolism; but the immediate causes of the characteristic (yet variable) leaf symptoms and the premature death of foliage have been almost entirely a matter for speculation. This communication is intended to direct attention to the fact that in barley, at least, putrescine is produced and accumulated under certain conditions of potassium deficiency, and that some of the observed symptoms may well be directly attributable to its presence.

A qualitative investigation, by means of paper chromatography, into the free ninhydrin-reacting compounds in barley leaves (F. J. Richards and E. Berner, in the press) revealed the frequent occurrence there of an unidentified basic substance. It was found in more than trace amounts only in potassium-deficient plants, and only in such of those as had not been supplied with either sodium or rubidium. Any of these alkali metals appeared to suppress its accumulation. Where it did occur it was present from an early age, increasing in quantity as the external symptoms of deficiency became acute.

In order to isolate and identify the substance, a large quantity of potassium-deficient barley was grown in 1951. Green laminæ, moribund leaves and stems from this material all contained the compound; indeed, on chromatograms from the moribund leaves it provided the most intense of all the ninhydrin spots. The substance was first isolated from the other ninhydrin-reacting compounds present in 75 per cent alcoholic extracts by elution on columns of 'Permutit' special sulphonated polystyrene resin; after passing hydrochloric acid and ammonium hydroxide through the charged columns the substance was removed by means of 0·2 *M* ammonium carbonate. The eluate was partially evaporated to remove the ammonia, acidified with hydrochloric acid and evaporated to dryness. The residue was then steam-distilled from a soda solution, acidified and evaporated nearly to dryness; a little ethanol was added and the substance thrown down with acetone. It was finally re-distilled and re-precipitated.

The isolated substance was indistinguishable from putrescine, whether in the form of hydrochloride, platinichloride or picrate; chromatographically, too, it behaved exactly like putrescine. The identification was confirmed by the production of identical X-ray powder photographs from the isolated substance and from putrescine hydrochloride; thanks are due to the Pedology Department of Rothamsted Experimental Station for taking these photographs.

The concentration of putrescine in the moribund potassium-deficient leaves is quite high, the yield indicating that the content of the free base must have been at least 0·15–0·2 per cent dry weight. No estimate of the content in green leaves has yet been made, but is, of course, lower than this.

Preliminary work involving feeding putrescine through the partially cut leaves of high-potassium plants has revealed toxic effects which bear close resemblances to some of the symptoms found in potassium-deficient barley. Chlorophyll disappears in patches and death soon follows. This may occur even on tillers remote from the one receiving the putrescine directly, distal parts of the leaves then being especially affected. The toxic symptoms induced by the free base, however, differ somewhat from those developed when the hydrochloride is supplied.

It is hoped that experiments in progress may throw some light on the origin of the amine (ornithine would seem to be the most likely precursor, but is not normally detectable in barley leaf extracts), and whether or not it is also produced, but metabolized immediately, in the presence of alkali metals.

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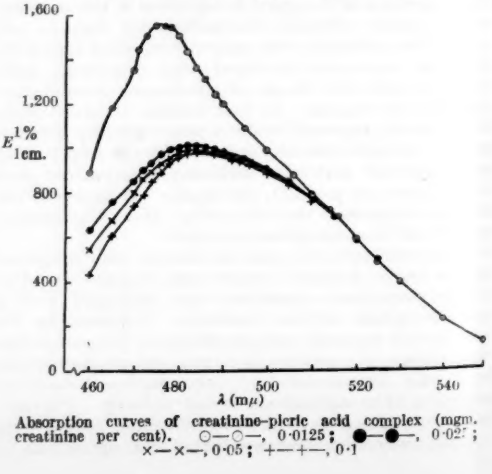
Determination of Creatinine

Creatinine is commonly determined in biological fluids by various modifications of the Jaffe reaction. The method is recognized as being non-specific and must be applied with caution unless there is a large excess of creatinine present over interfering substances. The specificity of the method has been greatly improved by Miller and Dubos[1].

Peters[2] has pointed out that a significant deviation from Beer's law becomes apparent at concentrations of creatinine greater than 5 mgm. per cent. This may be due to the bicolorimetric nature of the determination; the orange-red colour being a mixture of the red of the coloured creatinine complex and the yellow of unchanged picric acid. So far as is known, it has not been made clear that anomalies may also occur at low concentrations of creatinine.

As the accompanying graph shows, it has been found that if the absorption spectrum of the creatinine



Absorption curves of creatinine–picric acid complex (mgm. creatinine per cent). ○—○—, 0·0125; ●—●—, 0·025; ×—×—, 0·05; +—+—, 0·1

complex (against a picric acid compensator) is plotted at different concentrations of creatinine, not only does $\lambda_{max.}$ vary, but so also does E(1 per cent, 1 cm.).

Most clinical methods recommend that the colour produced in this reaction should be read using a 520-mμ filter. An explicit reason for this can now be given, for the absorption curves become closely convergent at a wave-length of about 515 mμ.

The findings indicate that the reaction postulated by Greenwald[3], in which one molecule of picric acid is said to react with one molecule of creatinine to produce a tautomeric (enolic) form of creatinine picrate, cannot be as simple as considered hitherto.

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University, Liverpool 3. April 2.

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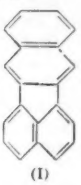
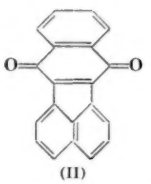
Isolation of 11 : 12-Benzfluoranthene from a Coal Tar Fraction

A recent description by Kruber and Oberkobusch[1] of the isolation from a coal tar pitch fraction of an unidentified hydrocarbon $C_{20}H_{12}$ (m.p. 216° C.) prompts me to record the isolation from a corresponding coal tar fraction of a hydrocarbon which possesses similar properties and which has been identified as 11 : 12-benzfluoranthene (I). The substance was obtained from a fraction (b.p. 269–279° C./5 mm.) produced by high-efficiency fractionation of the neutral portion of a distillate obtained during the production of pitch coke. By crystallizing the soft resinous fraction from ether, a yellow solid was obtained which was purified by the crystallization and subsequent decomposition of its 1 : 3 : 5-trinitrobenzene derivative. The pure hydrocarbon crystallized from benzene as very pale yellow needles, m.p. 216–217° C. It had a molecular formula of $C_{20}H_{12}$, and its ultra-violet absorption spectrum was identical with that published for 11 : 12-benzfluoranthene[2].



(I)



(II)

The identity of the hydrocarbon was confirmed by comparison with a synthetic specimen of 11 : 12-benzfluoranthene prepared according to the method described by Orchin and Reggel[2]. The following derivatives of the coal tar hydrocarbon were also identical with the corresponding complexes formed from the synthetic hydrocarbon: unstable picrate (red needles, m.p. 167–168° C.), 1 : 3 : 5-trinitrobenzene derivative (golden-yellow needles, m.p. 181–182° C.), 2 : 4 : 7-trinitrofluorenone derivative (orange-red microcrystals, m.p. 253–254° C.).

Oxidation of both the synthetic and coal tar hydrocarbons with potassium dichromate in acetic acid yielded a quinone which, after purification by chromatography on activated alumina, crystallized as bright red needles, m.p. 236–237° C. Analytical figures were in agreement with the formula $C_{20}H_{10}O_2$. Further oxidation produced naphthalic anhydride, indicating that the quinone has the structure (II), assigned to it by Moureu, Chovin and Rivoal[3].

A complete account of the investigation of the pitch-coking distillate will be published at a later date.

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July 22.

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Sugar Components of Blood and Urinary Glycoproteins: Confirmation of the Presence of Fucose by a New Reaction

During the course of a systematic study of the carbohydrate constituents of some glycoproteins of human and animal origin, a number of unexpected component sugars have been separated by paper chromatography. In particular, the presence of fucose has been definitely demonstrated in human serum mucoprotein and in normal human urinary proteins.

Serum mucoprotein was prepared by the method of Weumer *et al.*[1]. To prepare the urinary protein, normal urine was dialysed and concentrated to one-fifth of its original volume at room temperature and reduced pressure. Six volumes of alcohol were added to precipitate the proteins. An examination of this material by paper strip electrophoresis showed the presence of albumin, α_1, α_2 and β globulins, these latter in rather low concentration.

The glycoproteins were hydrolysed with 2 *N* sulphuric acid for 8 hr. at 100° C. in sealed tubes. The hydrolysates were neutralized to *p*H 4·5 with barium hydroxide and the clear filtrate concentrated to a suitable volume. Aliquots were then chromatographed using pyridine/amyl alcohol/water, phenol/water for 3 per cent ammonia, or butanol/ethanol/water as solvent systems. The chromatograms were sprayed with *p*-anisidine hydrochloride in butanol[2]. Mannose, galactose, and a hexosamine were found, corresponding to the results obtained by Werner and Odin[3] for ox seromucoid. The hexosamine was identified as glucosamine[4] and some of it is present in the native protein as the N-acetylated derivative. A faster moving component was invariably present on the chromatograms, however. It was found to have an R_F value corresponding to that of fucose in all the solvent systems used. The intensity of the spot relative to the other sugar components was greater in the urinary material than in the serum mucoprotein.

In order to confirm the identity of this sugar, advantage was taken of the fact that periodate oxidizes methylpentoses to formic acid and acetaldehyde, whereas simple aldoses and ketoses are oxidized to formic acid and formaldehyde[5]. Acetaldehyde can be readily detected by the Rimini reaction[6] with piperazine and nitroprusside, the full scope and limitations of which will be described elsewhere[7]. This test can be applied to paper chromatograms, which are sprayed with 2·5 per cent aqueous sodium metaperiodate. The oxidation is allowed to proceed for ten minutes and then the Rimini reagent is applied. This reagent must be prepared immediately before use by mixing 7 per cent aqueous sodium nitro-

prusside (1 vol.) with a saturated ethanolic solution of piperazine (3 vol.) and methanolic 1 per cent ethylene glycol (4 vol.). An intense blue spot slowly develops, in the presence of not less than 10 μgm. methyl pentose. The component in the hydrolysate believed to be fucose gave a strongly positive reaction in this test.

2-Deoxy sugars and the amino-acid threonine also give a blue colour under these conditions, but they can be distinguished from the methylpentose by comparison of R_F values and other reactions.

The presence of fucose in human blood-group substances has been shown by Bray and Stacey[8] and in human cervical mucus by Werner and Bergman[9]. Whether serum and urinary glycoproteins have any direct relationship with the blood-group substances, or whether fucose will be found together with other neutral sugars in other body tissues, is now being investigated.

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Slow Combustion of Cyclopropane

We have investigated the slow thermal oxidation of cyclopropane by the static method between 380° and 430° C. and at partial pressures of the reactants between 50 and 400 mm. The products are mainly carbon monoxide and water, with small amounts of carbon dioxide and formaldehyde, and the course of the reaction can readily be followed by pressure measurements. There is a period of negligible pressure change followed by rapid acceleration to a maximum rate, during which $\Delta p \propto \exp(\varphi t)$, where t is the time from the beginning of the reaction and φ a constant. Thus, as is the case for nearly all other hydrocarbons and their simple derivatives, the oxidation can be explained in a general fashion as a chain reaction with degenerate branching[1].

The temperature-range over which the rate is measurable overlaps the lower limit of the so-called 'high-temperature' region for slow hydrocarbon combustion, which is given[2] as approximately 400° C. It has been suggested[3] that the kinetics of the 'high-temperature' oxidation (for example, of methane, ethane, ethylene and propane above 390° C.) closely follow that of methane, for which the maximum rate of the reaction is represented by the expression $\rho(\text{max}) \propto [CH_4]^2.[O_2].P$, where P is the total pressure of the mixture[4]. Using cyclopropane, however, while Day and Pease[5] found that, as with methane, no cool flames are observed, the dependence of ρ(max) on the partial pressures of the reactants resembles more closely that exhibited by oxidations in the 'low-temperature' region (200°–300° C.), characterized by a very marked variation of ρ(max) with hydrocarbon concentration but little or no variation with oxygen or total pressure[6]. Thus, at any temperature there is a range of 'low' oxygen partial pressure within which $\rho(\text{max}) \propto p(C_3H_6).p(O_2)$, and a range of 'high' oxygen partial pressure where $\rho(\text{max}) \propto p^2(C_3H_6)$ and independent of $p(O_2)$. The latter dependence is in qualitative agreement with the results of three experiments reported by Day and Pease[5] for the oxidation at 370° C. The change of dependence usually takes place over a fairly small pressure range, and this 'critical partial pressure of oxygen' increases greatly on increasing $p(C_3H_6)$ or the temperature. In other words, at 'high' $p(O_2)$, 'low' $p(C_3H_6)$ and/or lower temperatures, the latter dependence is observed, whereas at 'low' $p(O_2)$, 'high' $p(C_3H_6)$ and/or higher temperatures the former dependence is observed. However, in no circumstances does the addition of nitrogen affect ρ(max) or the induction period.

In the 'low-temperature' region a change from dependence to independence of ρ(max) on $p(O_2)$, as this is increased at a constant value of the hydrocarbon pressure, has been reported for the oxidation of several hydrocarbons[6,7]. But it has hitherto been generally agreed that in the 'high-temperature' region ρ(max) is always strongly dependent on the oxygen concentration.

The variation of ρ(max) with temperature has been investigated at high and low oxygen pressures. In both cases the Arrhenius plots are straight lines with some curvature at the high- or low-temperature end respectively. The overall activation energies for the two regions of different dependence of ρ(max) on concentration, as calculated from the slopes of the straight portions, are the same (~ 35 kgm.cal./mole), and the curvatures appear to be due to alteration of dependence with the temperature. It is possible that some of the curved Arrhenius plots which have been reported by other workers[2] for gaseous oxidations are due to this cause.

It may be suggested that the kinetic results reported here are due to the structure of the cyclopropane molecule, which has been the subject of some controversy[8]. However, the molecule must presumably contain CH_2 groups, irrespective of the type of bond between the carbon atoms. Thus the work may be considered to cast some doubt on the view that hydrocarbon oxidations in the two temperature-ranges are kinetically very distinct; and, in fact, it is possible that ρ(max) would be independent of oxygen concentration at any temperature at which slow combustion can occur, if a high enough partial pressure of oxygen were used.

Further work is in progress and it is hoped to publish fuller details of the investigation in due course.

We wish to thank the Anglo-I. .nian Oil Company for a grant.

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FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, September 15—Friday, September 19

INSTITUTE OF METALS (at Oxford).—Annual Autumn Meeting.

Monday, September 15—Saturday, September 20

CEMENT AND CONCRETE ASSOCIATION in conjunction with the BUILDING RESEARCH STATION (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2; Monday only, September 15, at the Royal Institution, 21 Albemarle Street, London, W.1).—Third International Symposium on "The Chemistry of Cement".

Wednesday, September 17

OIL AND COLOUR CHEMISTS' ASSOCIATION, LONDON SECTION (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. P. J. Curtis: "Cadmium Pigments".*

Wednesday, September 17—Friday, September 19

BRITISH ECOLOGICAL SOCIETY (in the Department of Zoology, The University, Liverpool).—Autumn Meeting.

Thursday, September 18—Saturday, September 20

SOCIETY FOR WATER TREATMENT AND EXAMINATION (at Sheffield) —Autumn Meeting.

Friday, September 19—Saturday, September 20

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, The University, Glasgow), at 11 a.m.—Scientific Papers.

SOCIETY OF LEATHER TRADES' CHEMISTS (in the Large Chemistry Lecture Theatre, The University, Leeds).—Annual Conference.

Friday, September 19

At 2 p.m.—Prof. J. B. Speakman: "The Reactivity of Protein Fibres; some Analogies between Keratin and Collagen" (Fifth Procter Memorial Lecture).

Friday, September 19—Monday, September 22

ASLIB (at The Hayes, Swanwick, Derbyshire).—Twenty-seventh Annual Conference.

Friday, September 19

Prof. T. U. Matthew: "The Significance of Information in Present-day Industrial Society".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT (with an honours degree in biochemistry, or its equivalent) IN THE BIOCHEMISTRY DEPARTMENT—The Secretary, The University, Aberdeen (September 18).

LECTURER (with high academic and research qualifications) IN CHEMISTRY—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3 (September 19).

DEMONSTRATOR IN ELECTRICAL ENGINEERING AND PHYSICS—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (September 20).

SCIENTIST, Grade III (with a first- or second-class honours degree in physics, preferably with a knowledge of electronics, workshop practice, and general physics) at the Central Laboratory, Shade House, Bolton Road, Pendlebury—The Divisional Establishment Officer, National Coal Board, North-Western Division, 40 Portland Street, Manchester 1 (September 20).

ELECTRONIC ENGINEER for the construction and servicing of high gain amplifiers for physiological recordings at different frequencies—The Secretary, Maida Vale Hospital for Nervous Diseases, London, W.9 (September 21).

LECTURER IN BIOLOGY, to teach mainly zoology up to B.Sc. general degree standard—The Principal, Acton Technical College, High Street, Acton, London, W.3 (September 21).

NON-MEDICAL BIOCHEMIST (university graduate holding the B.Sc. in chemistry or biochemistry, or associate of the R.I.C.)—The Superintendent, Royal Hospital, West Street, Sheffield 1 (September 24).

STATISTICIAN (Scientific Officer grade)—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (September 24).

ENGINEERS to the Ministry of Supply in Lancashire, for inspection of wide variety of plant and equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.458/52A (September 27).

CROP PHYSIOLOGIST to work on effect of climatic factors prevailing in Scotland on growth and cropping of horticultural crops, an APPLIED GENETICIST for genetical studies, to develop varieties of horticultural plants for special use in Scotland, a MYCOLOGIST to work on problems connected with red core in strawberries, particularly those arising from development of physiological strains of this fungus, an ENTOMOLOGIST to work on incidence, life histories, pest range, etc., of insects which are known or may possibly act as vectors of virus diseases to horticultural crops in Scotland, a HORTICULTURAL BOTANIST to work on problem of vegetable culture in Scotland, and an ENTOMOLOGIST to act as field and laboratory assistant in the Plant Pathology Section —The Secretary, Scottish Horticultural Research Institute, Vernonholme, Riverside Drive, Dundee (September 30).

LECTURER IN PHYSIOLOGY—The Registrar, King's College, Newcastle-upon-Tyne (September 30).

LECTURER (Grade II) IN CHEMICAL PATHOLOGY, and an ASSISTANT LECTURER (Grade III) IN VETERINARY PATHOLOGY, at the Veterinary Field Station, Landford, Somerset—The Registrar and Secretary, The University, Bristol (September 30).

VETERINARY RESEARCH OFFICER in the Sudan Veterinary Service—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1 (September 30).

JUNIOR LECTURER IN BACTERIOLOGY—The Secretary, London Hospital Medical College, Turner Street, London, E.1 (October 4).

HEAD OF THE DEPARTMENT OF NATURAL SCIENCES, a SENIOR LECTURER OR LECTURER IN BOTANY, a SENIOR LECTURER OR LECTURER IN ENGINEERING, and a LECTURER IN GEOGRAPHY, in the Nigerian College of Arts, Science and Technology—The Secretary, Advisory Committee on Colonial Colleges, 15 Victoria Street, London, S.W.1 (October 6).

LECTURER IN BACTERIOLOGY, a LECTURER IN GEOLOGY, and a LECTURER IN PHILOSOPHY, at the University of Adelaide—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Adelaide, October 15).

CHIEF SEWAGE CHEMIST—The Town Clerk, Town Hall, Bradford, endorsed 'Chief Sewage Chemist' (October 17).

RESEARCH OFFICERS IN THE SOIL SURVEY AND PEDOLOGY SECTION, Division of Soils (initially at Adelaide and Canberra), for soil surveying and pedological investigations requiring approximately six to seven months each year in the field—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3958 (October 18).

LECTURERS and SENIOR LECTURERS IN PRIMARY AND NON-FERROUS METALLURGY, and a TEACHER IN COAL MINING, at the New South Wales University of Technology—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (October 27).

LECTURER IN PHYSICS (with special qualifications in theoretical physics)—The Secretary, Queen's University, Belfast (November 30).

LECTURER IN EXPERIMENTAL PHARMACOLOGY—The Secretary of the University Court, The University, Glasgow, W.2 (December 31).

ARROWROOT PROCESSING CHEMIST (with a degree in chemistry and experience in starch technology) in St. Vincent—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27106/62/52.

ASSISTANT DIRECTOR OF BOTANICAL GARDENS, Singapore—The Director of Recruitment (Colonial Office), Colonial Service, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27059/261.

ASSISTANTS (Grade A) TO TEACH MATHEMATICS up to degree standard —The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham, Essex.

BIOCHEMIST in the East African Tsetse and Trypanosomiasis Research and Reclamation Organization, to carry out research on animal and insect physiology in connexion with trypanosomiasis investigations in East Africa—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27106/63/52.

ENGINEER (Design) IN THE DEPARTMENT OF RURAL WATER DEVELOPMENT, Gold Coast—The Gold Coast Office, Melbourne House, Aldwych, London, W.C.2.

INSPECTOR OF MINES (with a degree or diploma of a recognized school of metalliferous mining and at least three years practical experience including underground mining) in Uganda—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting C.S.D.63/9/01.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Bulletin of the British Museum (Natural History). Geology, Vol. 1, No. 8: Cretaceous and Tertiary Foraminifera from the Middle East. By T. F. Grimsdale. Pp. 221–248+plates 20–25. (London: British Museum (Natural History), 1952.) 10*s.* [265

Selected Papers from the Royal Cancer Hospital and the Chester Beatty Research Institute, 1948–1949. Vol. 6. Pp. x+616. (London: Royal Cancer Hospital, 1952.) [265

Statistical Method in Industrial Production: being Papers given at a Conference held by the Industrial Applications Section of the Society in Sheffield, September 29th to October 1st, 1950. Pp. v+89. (London: Royal Statistical Society, 1951.) 7*s.* 6*d.* [265

Forestry Commission. Thirty-second Annual Report of the Forestry Commissioners for the Year ending September 30th, 1951. Pp. 82. (London: H.M. Stationery Office, 1952.) 3*s.* net. [275

Forestry Commission. Leaflet No. 1: The Large Pine Weevil (*Hylobius abietis*). Revised edition. Pp. 10. 6*d.* net. Leaflet No. 29: Pissodes Weevils. Pp. 12. 6*d.* net. (London: H.M. Stationery Office, 1952.) [275

London School of Hygiene and Tropical Medicine. Report on the Work of the School for the Year 1950–1951. Pp. 112. (London: London School of Hygiene and Tropical Medicine, 1952.) [275

Fifth Annual Report of the Advisory Council on Scientific Policy, 1951–1952. (Cmd. 8561.) Pp. iv+12. (London: H.M. Stationery Office, 1952.) 6*d.* net. [285

Department of Scientific and Industrial Research: Road Research Laboratory. Road Note No. 1: Recommendations for Tar Surface Dressings. Second edition. Pp. 10. (London: H.M. Stationery Office, 1952.) 9*d.* net. [285

War on Want: a Plan for World Development. Pp. 96. (London: Association for World Peace, 1952.) 1*s.* [295

Mushroom Research Association. Report for the Year 1951. Pp. 58. (Yaxley, Peterborough: Mushroom Research Association, 1952.) 5*s.* [56

Scottish Home Department: Freshwater and Salmon Fisheries Research. 2: Second Annual Report of the Supervisory Committee for Brown Trout Research, 1949–1950. Pp. 12+4 plates. 2*s.* 6*d.* net. 3: Third Annual Report of the Supervisory Committee for Brown Trout Research, 1950–1951. Pp. 14. 2*s.* net. (Edinburgh and London: H.M. Stationery Office, 1951–1952.) [56

Carnegie United Kingdom Trust. Thirty-eighth Annual Report, 1951. Pp. viii+48. (Dunfermline: Carnegie United Kingdom Trust, 1952.) [56

British Standard 1751:1952, General Purpose Glass Stopcocks. Pp. 10. 2s. net. British Standard 1792:1952, One-mark Graduated Flasks. Pp. 12. 2s. net. (London: British Standards Institution, 1952.) [56

Dollar Savings through Standards. Report of Survey to obtain Data on Savings derived from the use of Standards by American Industry. Pp. 32. (London: Mutual Security Agency, American Embassy, 1952.) [56

British Drug Houses, Ltd. Report and Accounts, 1951. Pp. 15. (London: British Drug Houses, Ltd., 1952.) [56

British Society for the Promotion of Vegetable Research. Second Annual Report, 1951. Pp. viii+83. (Warwick: National Vegetable Research Station, 1952.) [96

Depopulation and Rural Life in the Solway Counties. By Bertram Hutchinson. (N.S. 120.) Pp. iv+110+25 plates. Depopulation and Rural Life in the Tweed Valley. By Bertram Hutchinson. (N.S. 120b.) Pp. ii+60. Depopulation and Rural Life in Aberdeen and Banff. By Bertram Hutchinson. (N.S. 120c.) Pp. 63. Depopulation and Rural Life in Scotland. By Bertram Hutchinson. (N.S. 120d.) Pp. ii+36. (London: Social Survey, 1949.) [96

Bulletin of the British Museum (Natural History). Mineralogy, Vol. 1, No. 3: Oriented Rutile in a High-Temperature Andesine from Nigeria, by P. M. Game; Note on Anorthoclase from Nigeria, by J. R. F. Joyce and P. M. Game. Pp. 73–93+plates 5–6. (London: British Museum (Natural History), 1952.) 6s. [96

Department of Scientific and Industrial Research: National Physical Laboratory. Report for the Year 1951. Pp. viii+77. (London: H.M. Stationery Office, 1952.) 3s. net. [96

The Framework of Joint Consultation. By J. H. Smith and Miss R. J. Carey. (Nationalized Industry Series, 10.) Pp. iii+35. (Claygate: Acton Society Trust, 1952.) 2s. [116

Other Countries

Annual Report of the Director of the Museum of Comparative Zoology at Harvard College to the Provost of Harvard University for 1950–1951. Pp. 16. (Cambridge, Mass.: Harvard College, 1951.) [265

Kungl. Skogshögskolans Skrifter. Nr. 7: Förenta staternas massa- och pappers-industri med särskild hänsyn till dess råvaruförsörjning (U.S. Pulp and Paper Industry with special reference to its Supply of Raw Material). Av Th. Streyffert. Pp. 85. (Experimentalfältet: Kungl. Skogshögskolan, 1952.) [265

United Nations. Housing and Town and Country Planning Bulletin 5: Community Facilities and Services. Pp. 112. (New York: United Nations; London: H.M. Stationery Office, 1952.) 1.25 dollars; 9s. [265

Proceedings of the American Academy of Arts and Sciences. Vol. 81, No. 6: The Problem of Undeveloped Areas in Asia and Africa. By Francis B. Sayre. Pp. 283–298. (Boston, Mass.: American Academy of Arts and Sciences, 1952.) 40 cents. [265

Canada: Department of Mines and Technical Surveys. Annual Report, Fiscal Year ended March 31, 1951. Pp. 99. (Ottawa: King's Printer, 1951.) 50 cents. [265

Canada: Department of Mines and Technical Surveys: Geological Survey of Canada, Radioactivity Division. Prospecting for Uranium in Canada. By Officers of the Radioactivity Division. Pp. v+167. (Ottawa: Queen's Printer, 1952.) 50 cents. [265

Canada: Department of Mines and Technical Surveys: Geological Survey of Canada. Memoir 260: Geology and Coal Deposits of Minto and Chipman Map-areas, New Brunswick. By J. E. Muller. (No. 2499.) Pp. v+40+2 plates. 75 cents. Memoir 262: Ashcroft Map-area, British Columbia. By S. Duffell and K. C. McTaggart. (No. 2501.) Pp. vii+122 (4 plates). 75 cents. (Ottawa: Queen's Printer, 1952.) [265

First Symposium on Chemical-Biological Correlation, May 26–27, 1950. Sponsored by the Chemical-Biological Coordination Center of the National Research Council. Pp. v+415. (Washington, D.C.: National Academy of Sciences—National Research Council, 1951.) 4 dollars. [265

Bernice P. Bishop Museum. Bulletin 204: Filth-Inhabiting Flies of Guam. By George E. Bohart and J. Linsley Gressitt. Pp. vii+152+17 plates. Bulletin 205: Report of the Director for 1950. By Peter H. Buck (Te Rangi Hiroa). Pp. 35. Bulletin 206: Cerambycidæ of the Fiji Islands. By Lawrence S. Dillon and Elizabeth S. Dillon. Pp. iii+114. Bulletin 207: Pselaphidæ of Oceania, with special reference to the Fiji Islands. By Orlando Park. Pp. iii+60. (Honolulu: Bernice P. Bishop Museum, 1951–1952.) [265

Occasional Papers of the Bernice P. Bishop Museum. Vol. 20, No. 10: Fauna Samoanus (Scolytoidea), 1. By Karl E. Schedl. Pp. 131–156. Vol. 20, No. 11: Plants of Canton Island, Phoenix Islands. By Katharine Luomola. Pp. 157–174. Vol. 20, No. 12: Relationships of the Fijian Species of Apsilochorema (Trichoptera, Rhyacophilidæ). By Herbert H. Ross. Pp. 175–182. Vol. 20, No. 13: Some Central Pacific Crustaceans. By Charles Howard Edmondson. Pp. 183–244. Vol. 20, No. 14: A Revision of the Dipterous Family Canaceidæ. By Willis W. Wirth. Pp. 245–276. Vol. 20, No. 15: Ulidiinæ (Diptera, Otitidæ) of Australasian Regions. By George C. Steyskal. Pp. 277–288. (Honolulu: Bernice P. Bishop Museum, 1951–1952.) [275

Survey of Egypt. Survey Department Paper No. 51: The 'Ababda. Lecture delivered at the Sudanic Institute of Cairo, March 8th, 1950, by G. W. Murray. Pp. 23. (Giza: Survey of Egypt, 1951.) 200 milliemes. [285

University of California Publications in American Archæology and Ethnology. Vol. 45: The Tukuna. By Curt Nimuendajú. Edited by Robert H. Lowe; translated by William D. Hohenthal. Pp. viii+209 (18 plates). (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1952.) 3.50 dollars. [46

University of California Publications in Psychology. Vol. 7, No. 1: New Means of Studying Color Blindness and Normal Foveal Color Vision; with some Results and their Genetical Implications. By Gordon L. Walls and Ravenna W. Mathews. Pp. iv+172. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1952.) 2.50 dollars. [46

Conserve e derivati agrumari. Vol. 1, No. 1, Gennaio-Marzo. Pp. 60 (Palermo: *Conserve e derivati agrumari*, 1952.) 700 lire; per anno (4 numeri), 2500 lire. [46

Československá Otolaryngologie. Ročník 1, Číslo 1. Pp. 48. (Praha: Zdravotnické Nakladatelství, 1952.) [46

United States Department of Commerce: Coast and Geodetic Survey. Special Publication No. 260: Manual of Harmonic Constant Reductions. Pp. ii+74. (Washington, D.C.: Government Printing Office, 1952.) 35 cents. [46

Tidal Forces in the Sun's Corona due to Planets. By K. G. Meldahl. Part 3, Text. Pp. 14. (Copenhagen: Berlingske Forlag, 1952.) [46

Academia Scientiarum Fennica. Annales, Series A, 3: Geologica—Geographica. 27: Around Pitkaranta. By Pentti Eskola. Pp. 90+6 plates. 350 F.mk. 28: Topographic-Isostatic World Maps of the Effect of the Hayford Zones 10 to 1 for the Airy–Heiskanen and Pratt–Hayford Systems. By E. Niskanen and L. Kivioja. Pp. 6+5 maps. 200 F.mk. (Helsinki: Academia Scientiarum Fennica, 1951.) [56

World Health Organization. Monograph Series No. 8: Kwashiorkor in Africa. By Prof. J. F. Brock and Dr. M. Autret. Pp. 78+4 plates. (Geneva: World Health Organization; London: H.M. Stationery Office, 1952.) 5s.; 1 dollar; 4 Sw. francs. [56

World Health Organization. Technical Report Series No. 47: Expert Committee on Environmental Sanitation; Second Report. Pp. 21. 1s. 3d.; 15 cents; 0·60 Sw. franc. Technical Report Series No. 51: Expert Committee on Maternity Care; First Report, a Preliminary Survey. Pp. 23. 1s. 3d.; 15 cents; 0·60 Sw. franc. (Geneva: World Health Organization; London: H.M. Stationery Office, 1952.) [56

World Health Organization. Annual Epidemiological and Vital Statistics, 1939–1946. Part 2: Cases of and Deaths from Notifiable Diseases. Pp. 125–326. (Geneva: World Health Organization; London: H.M. Stationery Office, 1952.) 20s.; 4 dollars; 16 Sw. francs. [56

World Health Organization. Official Records of the WHO, No. 37: International Sanitary Regulations; Proceedings of the Special Committee and of the Fourth World Health Assembly on WHO Regulations, No. 2. Pp. iv+443. (Geneva: World Health Organization; London: H.M. Stationery Office, 1952.) 16s. 3d.; 2.25 dollars; 9 Sw. francs. [56

Department of Agriculture, Jamaica. Bulletin No. 48: Sample Survey of Production of Selected Agricultural Products, 1950. By W. D. Burrowes. Pp. 65. (Kingston: Department of Agriculture, 1952.) 3s. [56

United States Department of Commerce: National Bureau of Standards. Report 1050: Bibliography on Geiger–Müller Photon Counters. By Edward J. Walker. Pp. ii+16. (Washington, D.C.: National Bureau of Standards, 1952.) [56

British Guiana. Report of the Forest Department for the Year 1950. Pp. 37. (Georgetown: Forest Department, 1951.) [96

Publikationer fra det Meteorologiske Institut, Årboger. Isforholdene i de Arktiske Have (The State of the Ice in the Arctic Seas), 1949. Pp. 19+5 maps. (København: G.E.C. Gad, 1951.) [96

Acta Radiologica. Supplementum 94: Mass, Lipids, Pentose Nucleoproteins and Proteins determined in Nerve Cells by X-Ray Microradiography. By Sven-Olof Brattgård and Holger Hydén. Pp. 48. (Stockholm: Elanders Boktryckeri A.-B., 1952.) 15 kr. [96

University of Arkansas: Institute of Science and Technology. Research Series No. 21: Bibliography of Differential Thermal Analysis. By Prof. W. J. Smothers, Yao Chiang and Allan Wilson. Pp. iv+44. (Fayetteville: University of Arkansas, 1951.) [106

United Nations in Pictures. Pp. 48. (New York: United Nations; London: H.M. Stationery Office, 1952.) 3s. 9d.; 50 cents; 2 Sw. francs. [106

Looking at the United Nations. Pp. 32. (New York: United Nations; London: H.M. Stationery Office, 1952.) 3s. 9d.; 50 cents; 2 Sw. francs. [106

Thirty-second Annual Report of the Research Council of Alberta, 1951. Pp. 32. (Edmonton: Queen's Printer, 1952.) [106

XLVIII Jahresbericht des Sonnblickvereines für das Jahr 1950. Geleitet von Prof. Dr. F. Steinhauser. Pp 38. (Wein: Springer-Verlag, 1952.) 7s. [106

World Health Organization. Technical Report Series No. 49: Expert Committee on Nursing; Second Report. Pp. 20. (Geneva: World Health Organization; London: H.M. Stationery Office, 1952.) 1s. 3d.; 15 cents; 0·60 Sw. franc. [106

Supplement to the American Ephemeris, 1954. Total Eclipse of the Sun, June 30, 1954. Pp. 42. (Washington, D.C.; Government Printing Office, 1952.) 40 cents. [106

List of Scientific Papers published in the Middle East (Afghanistan, Cyprus, Egypt, Iran, Iraq, Israel, Lebanon, Pakistan, Sudan, Syria and Turkey) received by this Office between 1st November 1950 and 30th September 1951. No. 7. Pp. 77. (Cairo: Unesco Middle East Science Co-operation Office, 1951.) [106

Report of an International Conference on Elementary Particles, held at the Tata Institute of Fundamental Research, Bombay, on 14–22 December 1950. Pp. xiv+203. (Bombay: Tata Institute of Fundamental Research, 1952.) [116

Yale Conservation Studies. Vol. 1, No. 1. Pp. v+84. (New Haven, Conn.: Yale Conservation Club, 1952.) [116

Indian Forest Bulletin. No. 153: Indigenous Cellulosic Raw Materials for the Production of Pulp, Paper and Board, Part 4, Writing and Printing Papers for *Helicteres isora* Linn. (*Maror phal*). By R. V. Bhat and Man Mohan Singh. Pp. 11. 7 annas; 8d. No. 155: Indigenous Cellulosic Raw Materials for the Production of Pulp, Paper and Board, Part 5, Pulps for Strawboards from *Ulla* grass (*Themeda arundinacea*) and *Panni* grass (*Vetiveria zizanioides*). By R. V. Bhat and Man Mohan Singh. Pp. 6. 7 annas; 8d. (Delhi: Manager of Publications, 1952.) [116

Fieldiana. Botany, Vol. 24, Part 3: Flora of Guatemala. By Paul C. Standley and Julian A. Steyermark. Pp. v+432. (Chicago: Chicago Natural History Museum, 1952.) 4.50 dollars. [126

O.N.E.R.A. Publication No. 51: Métallographie de l'aluminium et de ses alliages; emploi du polissage électrolytique. Par P. A. Jacquet. Pp. iv+64. (Chatillon-sous-Bagneux: Office National d'Études et de Recherches Aéronautiques, 1952.) [126